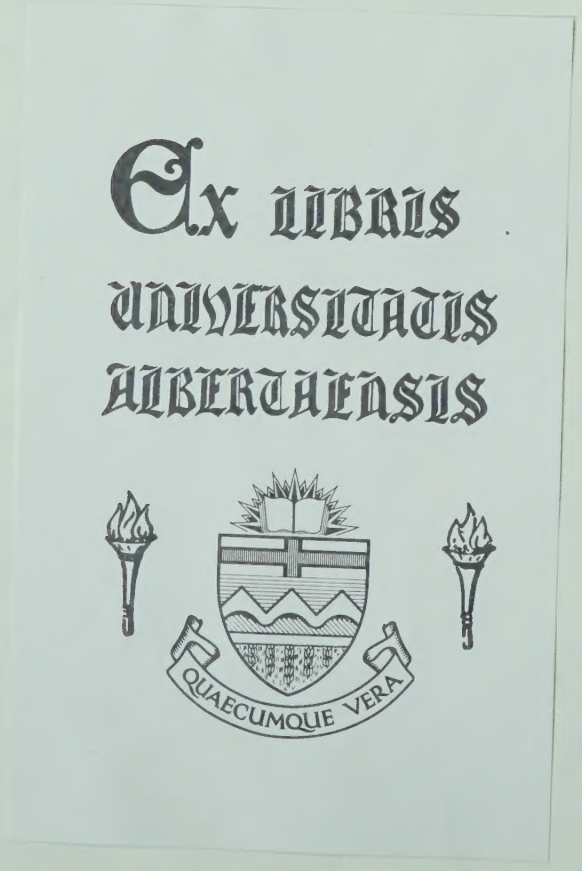

THE UNIVERSITY OF ALBERTA

FIVE STRATEGIES OF PRESENTATION OF PAIRED-ASSOCIATES IN COMPUTER ASSISTED INSTRUCTION

by

© DONALD W. PRICE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF EDUCATION

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

SPRING, 1970

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Five Strategies of Presentation of Paired-Associates in Computer Assisted Instruction" submitted by Donald W. Price in partial fulfillment of the requirements for the degree of Master of Education.

ABSTRACT

The purpose of this study was to test the effectiveness of five different methods of teaching paired-associates on the IBM 1500. Effectiveness was measured by two different criteria tests - a recall test and a recognition test. Each of these criterion tests was used to measure the effectiveness of the methods over two different time periods -- immediately after the teaching sessions and one week after the teaching session. The criterion used was amount learned per unit time. Sixty-eight, twelve to fourteen year old subjects were randomly assigned to the five teaching methods and two criterion test types.

The results of this experiment, though not significant, would tend to indicate that the Prompt methods of teaching paired-associates was the most effective of those tried if one considers short term effects. If long term effects or retention are considered in relation to recall tasks, there appears to be little differential effect among the five methods tested. Recognition tasks on the other hand tend to remain more consistent over time and thus the Prompt method would be considered superior for this type of task (at least for short term retention tasks - i.e. one or two weeks).

No interaction between the constructed response and recognition criterion tests was found, indicating that the teaching methods did not appear to differentially affect the subjects' achievement as measured by two different procedures.

The S-R method of teaching, though resulting in the second highest mean criterion score, had the lowest return rate for the

second session, indicating that the motivation factor cannot be ignored in any teaching method chosen in C.A.I.

ACKNOWLEDGEMENTS

I am grateful for the help and co-operation received from many sources in the execution of this investigation:

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Dr. D. Fitzgerald and Dr. P. A. McFetridge whose expert advise and encouragement added depth to this writer's perceptions of the field he has studied.

Mrs. H. Hansen of the Central Volunteer Bureau for her hours of dedication in obtaining subjects for the experiment on terribly short notice.

Most of all I would like to thank my wife, Yvonne, and my children, Kirby, Vincent, Donna, and Deborah. Their patience has made the completion of this document possible.

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CHAPTER I

THE PROBLEM, ITS NATURE AND SIGNIFICANCE

I. INTRODUCTION

When the computer was first combined with the typewriter, cathode ray tube and other sensing devices it marked the beginning of a new era in the development of education. This new era may be as far reaching and drastic a change as to rival any of the great social revolutions of the past. The application of computers to instruction is growing so fast it makes papers written as recently as six years ago obsolete. The application which is the focus of the present study has popularly been called "Computer Assisted Instruction" (C.A.I.) and is not to be confused with programmed learning which generally refers to programmed text books or mechanical teaching machines of the Skinner type (Skinner 1958).

The faith and hope for the future where learning will be interesting for everyone, where failure will vanish and where all students, rich or poor, will have equal opportunities to develop their potential, lies in the hands of the educators who are willing and able to adjust the educational system on the basis of empirical evidence. They must design the system in such a way that empirical feedback is always available for decision making. One of the ways this seemingly impossible task may be approximated is through the intelligent implementation and use of the more sophisticated computers which are now available and will be developed in the future. This project is one of the many which will be needed if C.A.I. is to advance and indeed if

education is to advance. What makes research of this nature mandatory in the C.A.I. field is the need to optimize the efficiency of any such teaching system so that the cost per student taught will become much lower and eventually competitive with conventional systems. The world economic and ideological race as well as the information explosion is further incentive to increase our schools' efficiency. In this author's opinion the computer has a very definite major role to play in this respect.

II. THE PROBLEM AND ITS IMPORTANCE

The main purpose of this study was to investigate ways of improving the efficiency of automated teaching. More specifically, an attempt was made to discover ways of increasing the efficiency of teaching on the IBM 1500 computerized teaching machine through a study of five strategies of teaching paired associates.

The methods of teaching the paired associates were derived partly from the programmed learning field and partly from the writer's and his associates' experience in the C.A.I. area. Four of the five methods parallelled as closely as possible the methods described in the literature on programmed learning with the exception that they were adapted for presentation on the computer (the ultimate objective being that no human would have to intervene during the entire teaching and testing process). The remaining method was one which is uniquely a C.A.I. method in that no mechanical teaching machine or programmed text book could teach in a similar way.

There are three main sections to this study:

1. An investigation into the differential effect of the

teaching methods as studied over different criterion measures.

2. A study of the differential effect of the teaching methods as affected by time and as measured by different criterion tests.
3. An attempt to relate the procedure and results to current learning theory.

A rationale for choosing the investigation of the teaching of paired-associates as an important indication of a general teaching situation may be presented as follows. It may be possible to generalize from the teaching of paired-associates because some of what is now taught in school is of the paired-associate type or may be broken down into a variation of paired-associate learning. For example a concept such as the relative mass of objects composed of different materials is associated with the word specific gravity. Kinematics is associated with a particular branch of physics and elicits a different response than does the stimulus light. When one wants to learn a new word he looks in the dictionary and is given a list of other words with which he is to associate the word in question and with which, hopefully, new meaning will be associated. One "knows a subject" or "has learned a subject" if he can use the shorthand, the code or the vocabulary of that subject. The need for such a code or abbreviated way of saying things arises out of the need to communicate vast numbers of paired-associates in an instant. For example a race driver, who when trying to communicate with his mechanic, would say "the rate of change of position of my car with respect to time squared is too small,"

(instead of "not enough acceleration") would still be in the starting position when the winner crossed the finish line. The assumption will thus be made that an important facet of learning is the pairing of sounds or labels with objects and with constructs. The sound "kar" is associated with a four wheeled metallic vehicle which ingests people, moves off, then spits them out. Or it is associated with marks on a piece of paper which look like "car". This same sound may eventually become associated with girls or the hypothetical construct "fun".

Skinner's learning theory and his discussion of the utility of teaching machines is based on the assumption that everything can be broken down into simple enough terms that virtually all of the people trying a particular frame (or unit of learning) will get it correct. In almost any subject we study, "learning the subject" consists in fact of learning the language or code of the subject. We explain some construct, then attach a name to it and if that name elicits the construct (or vice versa) we say we have learned it. For the above reasons then, the writer believes that principles discovered in the study of paired-associate learning may be applied to a much wider field of learning which may not at first be thought of as paired-associate in nature.

III. DESIGN AND PROCEDURE OF THE STUDY

In this study five teaching methods, two criterion tests and two time intervals of testing were studied. The levels of the three factors mentioned above are described below.

Method One (Partial Confirmation) This method presents the stimulus to the subject, elicits a response, checks the response and either feeds back the checked response requesting another response or flashes the word RIGHT on the C.R.T. If the subject uses all the alloted tries the correct response is flashed on the screen and he moves on to the next question. Each response is checked by retaining any character in the response which matches exactly with a character in the same position in the criterion response or any three or more consecutive characters in the criterion response. Those characters which do not match are replaced by hyphens. Then the checked response is flashed on the C.R.T.

Method Two (Confirmation) This method presents the stimulus to the subject, elicits a response, checks the response then either flashes the word WRONG on the screen and presents the criterion response or flashes the word RIGHT on the screen and proceeds to the next question.

Method Three (Prompt) This method presents the criterion response, presents the stimulus, elicits a response from the subject while the criterion response and stimulus are still on the C.R.T.

Method Four (Multiple Choice) This method presents the stimulus, then presents six possible criterion responses from which the subject is required to point one for his choice of a response. If the selection is correct all the remaining distractors are erased from the screen and the word RIGHT is flashed on the screen. If the selection is wrong the word WRONG is flashed on the screen and the incorrect selection erased from the screen. The subject proceeds until he points to the

correct distractor.

Method Five (Stimulus-Response) This method presents the subject with the stimulus and criterion response simultaneously. When the subject hits the space bar on the terminal the next pair of associates is presented.

Test 1 (Constructed Response) This criterion test presents the stimulus (the English part) to the subject then requests him to type in his response. The response is checked and the next question asked.

Test 2 (Multiple Choice) This criterion test presents the stimulus (the English part) and six distractors to the subject who responds by pointing to one of the distractors.

Time One This is the time at which the first presentation of the criterion test is made and occurs immediately after the teaching methods are finished.

Time Two This is the time at which the second presentation of the criterion test is made and is one week after Time One.

The analysis of this study was divided into three distinct parts:

Part one: a study of the differential effects of teaching methods over criterion tests and a study of the teaching methods on the criterion tests

Part two: a study of the differential effects of the teaching methods over time (for each criterion test) and a study of the differential effects of time on the results of the teaching methods (as measured by Test 1 and Test 2)

Part three: a set of planned comparisons to test various

questions related to learning theory and applicable to this study.

Random samples of students listed in the Central Volunteer Bureau's files were bussed to the University of Alberta in groups of ten. These ten were randomly assigned two to a method and five to each of the two criterion tests. Although some needed additional help most of the students learned how to use the terminals and proceeded through the program entirely under the direction of the computer. After proceeding through the teaching program and taking the criterion test of achievement the student waited one week (to the hour) before being bussed to the University for a second testing session with the same criterion test on which he had previously been examined.

The computer program was entirely written by the author in the Coursewriter II language and was pretested before the experimental run.

IV. DEFINITION OF TERMS

Achievement in the context of this study will mean the number of paired-associates learned per unit time. If one learns more than someone else in the same amount of time he shall be considered to have achieved more.

Amount Learned shall mean the number of paired-associates correctly reproduced in the different criterion tests. It shall be referred to as and measured by the score on these criterion tests.

Cathode Ray Tube (C.R.T.) the television-like tube on which the text of all the material presented to the student is displayed. Is often referred to as the screen.

Computer Assisted Instruction (C.A.I.) is the name given to a teaching process which makes extensive use of a computer in presenting, testing and interacting with the student.

Constructed Response refers to the type of response whereby the subject fabricates or constructs his answer without external cues. This is in contrast to the multiple choice type of response where the answer is already constructed for him and he has only to recognize the response from a set of alternatives.

Information Feedback Interval refers to the interval of time between a student's response and the moment he is fed back information based on that response.

Linear Programming refers to a program where all the subjects follow the same pattern of questions and all questions or frames are in one sequential pattern. There is only one route a student can follow from the beginning to end, the only variations among students being the time taken to complete the program.

Method One (M1) refers to and is synonymous with the Partial Confirmation Method of teaching.

Method Two (M2) refers to and is synonymous with the Confirmation Method of teaching.

Method Three (M3) refers to and is synonymous with the Prompt Method of teaching.

Method Four (M4) refers to and is synonymous with the Multiple Choice.

Method Five (M5) refers to and is synonymous with the S-R Method of teaching.

Post Information Feedback Interval refers to the time between the

Information Feedback and the beginning of the next stimulus (or question).

V. OUTLINE OF STUDY

A review of pertinent literature is presented in Chapter II. A special chapter detailing the teaching methods used, how they relate to the literature and the questions they elicit will be labeled Chapter III, THE METHODS. Chapter IV consists of a detailed description of the design and the statistical procedures used in analysing the data. Chapter V includes the results of the statistical analysis and Chapter VI summarizes the study and presents the conclusions, limitations and implications for further research.

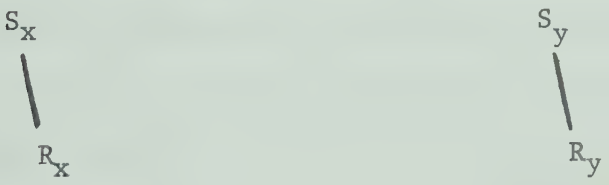
CHAPTER II

REVIEW OF THE LITERATURE

The classical explanation of how one comes to associate (learn) two words or concepts may be presented by paraphrasing Staats and Staats discourse on paired-associate learning (Staats and Staats 1963). Two stimulii are presented to a subject who is required to associate them in such a way as to be able, upon presentation with one S, to respond with the other. The association of these S's may follow the tenets of classical conditioning. For example, in the common paired associations of words:

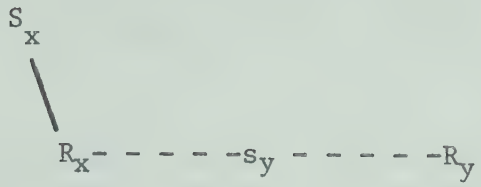
1. One word acts as the stimulus (S_x) which elicits the response (R_x). (S_x) may be the typewritten word dog; the R_x would then be the subject saying, either overtly or covertly, "dog".
2. The other word (S_y) would also elicit a response (R_y).

Figure 1



Simply by being presented together a relationship is set up whereby S_x elicits R_x which in turn produces a stimulus which will elicit R_y without the physical presence of S_y.

Figure 2



Even though most text books will describe the process of associating two words in approximately the same way, many of the studies which investigated methods for doing this differed in their approaches to the problem as well as in their results. With respect to automated learning the programmed text book and mechanical teaching machine enthusiasts seem to have done the most work in this area.

Holland (p. 77 undated) in his booklet Research on Programming Variables describes two main methods of presenting "constructed response" (see definitions) material in classical linear programming sequences. They are the Prompting and the Confirmation methods.

Prompting - means the criterion response term is shown before there is an opportunity for an overt response from the subject.

Confirmation-sometimes called the anticipation method; means the subject is presented a stimulus, required to respond and then he is shown the criterion response term (checking).

The Confirmation method advocated by Skinner (1958) has been found most efficient by researchers such as Gagne and Brown (1961).

Angeli and Lumsdaine (1961) suggest there is no significant difference between the prompt and the confirmation methods of presentation. Kopstein and Roshal (1955), Cook and Kendler (1956), Cook and Spitzer (1960), Kopstein and Shillestad (1961), and Stolurow and

Lippert (1963) all report the superiority of prompting over confirmation. Holland (p. 75 undated) after extensive reading in this area said:

> None of the experiments found an unequivocal advantage for partial cueing over the standard anticipation (confirmation) method, though slight non-significant differences were common. The studies taken as a whole suggest a slight advantage for partial prompting over the anticipation method.

An interesting study was done by Sidowski, Kopstein and Shillestad (1961). They defined six variations of the Confirmation and Prompt type of presentation:

1. Confirmation - stimulus presented, subject required to respond overtly, response (correct answer) is then presented subject.
2. Prompting - stimulus presented subject, response presented subject, subject required to respond overtly.
3. Confirmation Prompt - stimulus presented, subject responds, response is presented, then subject is required to copy response.
4. Prompt S-R - stimulus presented, stimulus and response presented, subject then required to respond.
5. Confirmation S-R - stimulus presented, subject responds, then stimulus and response presented together.
6. Simultaneous Observation - stimulus and response presented simultaneously but subject does <u>not</u> respond overtly.

Number 2 and 3 methods were shown to be significantly superior on criterion tests to any of the three confirmation methods. Even simultaneous observation was significantly better than the confirmation methods.

Other researchers, Hershberger and Torry (1965), and Faust and Anderson (1967), have refined the prompt method somewhat and report that it is most effective when the item difficulty is fairly high.

They report that if the item is too easy the subject can get into the habit of merely copying without thinking about what he is doing.

Other issues in programming besides those previously mentioned have arisen in the past and will be mentioned only as they relate to the above.

1. Constructed response (C-R) verses Multiple choice (M-C): Both confirmation and prompting types of presentations are of the constructed response type. There is, however, some controversy over the desirability of this mode of response over the simple multiple choice. For one thing it is usually much more time consuming than the multiple choice mode. (In fact Sidowski, Kopstein and Shillestad (1961) had results which indicate the method not requiring an overt response was not less effective than those which did - hinting that overt responding may not even be necessary . Williams (1967) found that students taking a course designed with a combination of constructed response (on technical items) and multiple choice (on general items) did significantly better on a C-R post test than did those taking a course designed with randomly mixed C-R and M-C type items.
2. Pacing: Two studies, Briggs, Ploshinski, and Jones (1959), Alter and Silverman (1962), found that programmer paced or student paced teaching programs seemed to have little differential effect on outcomes.
3. The information feedback interval (I-F) (see definitions) and post information feedback interval (post I-F): I-F interval is pertinent only to the confirmation presentation while post I-F interval applies to both systems. Studies of operant condi-

tioning suggest that the sooner reinforcement follows a response the quicker and stronger the S-R relationship will be established (Skinner, 1953). If it is assumed that most programs are written to minimize incorrect responses it may safely be said they should be given immediately after a response. Bourne and Bunderson (1965), and Boersma (1966) report no significant difference in learning when the I-F delay is varied. However, they had conflicting results with respect to post I-F delay. Bourne and Bunderson (1965) found delay of post I-F resulted in fewer errors while Boersma (1966) found no difference.

Zinn (1967) in his article Languages for Programming Conversational Use of Computers for Instruction mentions that over twenty computer languages and dialects have been developed especially for C.A.I. Several of these languages have the capability of feeding back to the student a partially corrected response and asking him to try again. Undoubtedly this feature has been used in many of the C.A.I. courses which have been written in the last few years. However this author has been unable to find any studies in the C.A.I. area which pertain specifically to the teaching of paired associates (this included a search of the latest edition of the ENTELEK Programmed Instruction Guide List of Courses which lists thousands of research studies recently conducted in the C.A.I. and programmed learning field). The writer thus feels that a study into the different methods of teaching paired-associates, a process of fundamental importance to learning, may shed some light on how C.A.I. programs can be made more effective.

Although there seems to be little concensus on which method of teaching used by the programmed learning specialists is superior, an attempt was made to adapt four of the more popular methods to the IBM 1500 C.A.I. machine along with one method particular to a C.A.I. machine, in an attempt to establish the superiority of any one of these methods over the others. Bourne and Bunderson (1965) used a multiple-choice type test as their criterion measure. Others such as Kopstein and Roshal (1955) or Faust and Anderson (1967) used constructed response criterion tests. Because the two types of criterion measures are fundamentally different (the constructed response test is a recall task while the multiple choice test is a recognition task) it was decided to include a test-type of factor in this study.

CHAPTER III

OUTLINE OF METHODS AND THEORY

I. THE METHODS

A brief outline of each of the five methods of presentation will now be given. When applicable, differences between the C.A.I. method (the computer adapted method) and the method as used by the programmed learning specialists will be outlined. A more detailed description of the C.A.I. methods and flow-charts for each method are described in the documentation of the computer program contained in Appendix C.

A. Partial Confirmation Method (Method One)

Classical

This method was impossible with the technology available to classical programmers.

C.A.I.

The stimulus is presented on the C.R.T. and the subject is required to type in his response. After being compared with the correct answer and determined as incorrect those parts of the response which are correct are retained and displayed on the C.R.T. immediately after (in time) the word "WRONG" is flashed on the C.R.T. and then the subject is presented with the next problem. Each incorrect response is checked by retaining any character in the response which matches exactly with the character in the same position in the criterion response or any three or more consecutive characters in the response which match any three or more consecutive characters in the criterion

response. Those characters which do not match are replaced by hyphens and the checked response flashed on the screen. The student is then asked to respond again provided he has not used all the allotted tries. For responses with less than 50 per cent of the characters correct and no improvement over repeated tries a maximum of three additional chances are given. If he has more than 49 per cent of the word correct five chances are allowed. If a subject's current response is an improvement over his previous response he is allowed an additional response even though he may have been over the allotted three or five chance limit.

For example: if the keyed response was Fluoroscope and the student's response was Flour the computer would respond first with the word "WRONG" then would display "Fl--r-------". Thus the student is informed that he got three characters correct and that there are eleven characters in the correct response. He will then be asked to try again.

B. The Confirmation Method (Method Two)

Classical

A question or problem (the stimulus) is presented the subject in the form of printed text on paper. It may be a question, with a space provided for the student to write his answer (response) or it may be a statement in which a blank is located. The student is required to write a word (the response) in the blank which makes the statement true and sensible. He then advances the frame or turns the page to reveal the answer. Regardless of whether or not he is correct he moves on to the next question, or frame.

C.A.I.

The student is presented with the problem on the C.R.T. He is required to type his answer (response) on a keyboard which automatically

displays it on the C.R.T. screen immediately below the question. If he is correct, the word "RIGHT" is flashed on the screen to the right of the question and response, which are still displayed on the screen. If he is wrong the word "WRONG" is displayed, his answer is erased and the words "The correct answer is _____" replace it. The sentence is positioned so that the correct response is immediately below the question word.

Differences

In the programmed method the student must realize that his answer and the keyed answer are the same or mean the same thing. All the C.A.I. method requires is that the student realize that the letters "RIGHT" mean he did what was asked of him and that the letters "WRONG" mean that he did not. The programmed method usually requires that the keyed answer be physically separated from the students' response. In the C.A.I. method the keyed answer is located immediately below the response and thus differences between the response and the keyed answer are more readily discernible.

C. Prompt Method (Method Three)

Classical

In this method both the required response and the stimulus word are presented together in the context of a sentence or a paragraph. The student has only to locate the correct word and copy it down in the space provided. The keyed answer is not revealed and the student never really knows whether or not he is correct. Regardless of whether the response is correct or wrong the subject goes on to the next problem.

C.A.I.

Stimulus and response words are presented together in a sentence or paragraph which is displayed on the C.R.T. The subject's response is displayed on the C.R.T. as he types it out. He then goes on to the next problem without getting any further feedback.

Differences

The only difference between these two methods is that the student writes in the answer in one case and types in the answer in the other.

D. Multiple Choice (Method Four)

Classical

The stimulus is presented and the subject is required to check off (or write down the lable of) one of the several alternative responses presented to him. These alternatives may be in the form of a list of answers printed on a page or (in the case of the more advanced electro-mechanical teaching machines A.T.A. Outline (1962)), several alternative buttons. In the case of the programmed text books and mechanical teaching machines the frame is then advanced and the label of the correct response displayed. (The electro-mechanical teaching machine could automatically determine whether or not the right button had been pushed and thus presented the course author with alternatives of having the student try again or going on to the correct answer and then the next problem. However the extreme cost limited the amount of use to which this machine was put and thus little is known of its usefulness or of its advantages over other programming methods.)

C.A.I.

This method is almost the same except for the fact that the text is presented on the C.R.T. and the student points to his choice of

alternatives with a light sensitive stylus (light pen). If he is correct the word "RIGHT" is flashed on the screen and all the incorrect responses are erased. After viewing the correct response for several seconds he then goes on to the next problem. If an incorrect distractor is pointed to, the word "WRONG" is flashed on the screen and that distractor is erased. The student then tries again.

Differences

The C.A.I. method has a consistent way of telling the student whether or not he is correct. i.e. By flashing the word "RIGHT" or "WRONG" on the screen. The classical method requires the student to match labels which may be different for each problem. Feedback is immediate for the C.A.I. method. In the classical context the student must determine what the correct answer is by performing some further task (further to responding), such as turning the page or turning to the next frame. He then must decide whether or not his answer is the same as that given. Then he may or may not interpret his correct response positively.

E. The Stimulus-Response Method (Method Five)

Classical

This method requires an electronic apparatus for pacing the presentation of the stimulus and response together for a specified amount of time. (Sidowski, Kopstein, and Shillested, 1961). Presumably any machine like a tachistoscope or a timed film strip projector may be used. Nothing more than the two words or concepts to be paired are presented. There is no response required from the subject other than the reading of the associates to himself.

C.A.I.

This method is exactly the same as the Classical approach except it is presented on the C.R.T. No overt response is required from the subject. Each pair is presented for five seconds then the next pair is presented for a similar time.

Differences

None

THE CRITERION TESTS

A. Constructed Response (Test 1)

This type of test requires the student to spell out his response. He must type in the complete answer. The actual format of presentation is very much like the stimulus presentation in the Confirmation method mentioned above.

B. Multiple Choice (Test 2)

All the student will have to do is point, with the light pencil, (see "The Machine" Appendix B) to one of the alternative answers presented to him.

In the present study, to minimize problems due to lack of familiarity with the keyboard or light pen, an exercise section was included in all programs.

LIMITATIONS OF CLASSICAL PROGRAMMING

When one talks of a constructed response in regard to a programmed text or mechanical teaching machine almost inevitably he is referring to the student or subject writing the required response in a blank space on the text. To correct his answer the student is

required to observe the keyed answer then determine whether or not his is the same (in the confirmation type of approach). If the student wrote an answer which was synonymous or which was an alternate he would be required to recognize the fact himself and even then he may not be really sure of the correctness of his answer. A student could conceivably think his answers are the same as the keyed answers while all the time they are wrong. His error would not be detected until the criterion tests (assuming the test was not self scored).

The use of C.A.I., on the other hand, makes it possible to analyse each response and tell the student exactly whether he is correct, partially correct, or whether he is wrong, by simply presenting him with the word "correct", or with a pleasing picture such as a smiling face, a star, etc., or any other sign which cannot be misinterpreted. In addition to this, the student can be informed whether or not his response was correct without telling him what the correct answer is (a feat which is impossible with constructed responses as they have been used in the past).

II. THEORY

The following theory may lend some support to each of the methods being tested. In each case the computer adapted version will be the method refered to.

A. PARTIAL CONFIRMATION

This method differs from the classical confirmation method in four important ways:

1. It eliminates punishment by never flashing the word "WRONG" on the screen. It could be considered continuous rein-

forcement (except when the student gets no letters of the response correct) because it always shows the student the parts of the response which he got correct and encourages him to try again.

2. It does not leave to chance (as does the confirmation method) the possibility that the student will try to find for himself the differences between his incorrect responses and the correct response. The differences are pointed out explicitly.
3. The replacements for the parts of the response which the subject gets wrong are not given to him. He must think or guess to fill in the incorrect parts and presumably the extra effort required will further point out the differences between his original response and the correct response.
4. The subject is required to correct his mistakes overtly whereas in the other methods he is only, at best, allowed to make a covert correction (a situation analogous to making a student write out a corrected spelling word as opposed to merely giving him the correct version and asking him to notice if his word is correct).

Another feature of this method is that it allows the subject to learn at a slower or a more rapid rate depending on the individual. As he tries to fill in the erroneous spaces in his original response he may take three tries while filling in the three different errors. Each loop would emphasize the particular position (the one just corrected) which holds a particular item (the correct character

just entered). The subject can then devote his attention to the other errors - - as a group or individually, whichever the subject prefers or is able to manage.

B. CONFIRMATION

Skinner proposed a teaching machine, using the confirmation method of presentation, as a working example of his theories on operant conditioning. He viewed the act of getting a problem correct as a positive reinforcing event and thus a motivating force for the repeated elicitation of the same response when presented with an equivalent stimulus in the future. The instances in which the subject made incorrect responses and the occurrence of the word "WRONG" could be viewed as punishment and thus would tend to suppress that action in the future (Hilgard, 1958).

Since the correct answer is displayed after the subject produces an incorrect response the subject is able to discover differences between his response and the acceptable response. He should thus be able to make a clear distinction and adjust accordingly in future encounters with a similar stimulus. The subject, by looking at the correct answer, will determine where his answer is different from the correct answer and will know where to avoid a similar mistake in the future.

C. PROMPT

This method seems to negate the need for reinforcement or even the need for feedback. Since the S and R are couched in the context of a sentence, the subject is required to differentiate the

given stimulus from all the other possible stimuli in the paragraph and then make the association with the correct response. For example a typical unit of learning using the prompt method is the following:

> In Latin a dog is a "canis" while the army is the "exercitus" and "puer" means boy.
>
> Army is _____.

First the subject has to find the stimulus which is similar to or the same as "army". To do this he must first differentiate between dog, army, and boy. While doing this he may reason "Dog is canis and dog is not army, therefore canis is not army. Army is exercitus and army is army, therefore the required response is exercitus." The set of units for the prompt method are shown in Appendix E.

D. MULTIPLE CHOICE

This method allows the student to differentiate between various possible answers before making a response. If he is correct he will receive a reward in the form of a "RIGHT" flashed on the screen. "Punishment" will be administered if the response is incorrect (the word "WRONG" will be flashed on the screen). Since all but the correct response will be erased from the screen there will be no chance for the subject to discover differences between his response and the correct response.

E. STIMULUS-RESPONSE

If Staats and Staats (1963) are correct the mere fact that S and R are being presented together is enough to make the required associations. The advantage of this system is that the material to be taught can be presented much more frequently than in other methods.

Frequency of presentation may be more important in setting up stable associations than the more complicated adjuncts of the other methods.

A COMPARISON OF THE THEORIES INVOLVED

Several different theories and partial theories are distributed among the five methods. Some are common to several methods, others are unique. Figure 3 shows the differences.

The categories mentioned above were arrived at largely on an intuitive basis and are based to a certain extent on the following assumptions:

1. That flashing the word "WRONG" on the screen acts as punishment.
2. That flashing the word "RIGHT" on the screen acts as reward.

III. QUESTIONS

Assuming the statements made about the six features or categories mentioned above are true the following statements should be supported by this study. (The "questions" are presented in the affirmative for greater clarity).

1. (a) If the mean for the S-R method on both criterion tests is significantly (.10) larger than all the other methods, then some support will be given to the premise that overt responses are not necessary for the learning of paired-associates.

   (b) If the S-R mean is significantly lower than all other means on the Constructed Response Criterion Test (C.R. Test) and significantly higher than the inter-groups mean on the M.C. Test then support will be lent to the

Figure 3

UNIQUE FEATURES OF THE TEACHING METHODS

Feature	Teaching Method Containing Feature
1. Requires overt responses	Partial Confirmation (P.C.) Confirmation (C) Multiple Choice (M.C.) Prompt (P)
2. Gives reward for correct response	P.C., C., M.C.
3. Provides opportunity to discover differences between subject's response and required response	P.C., C.
4. Gives feedback	P.C., C., M.C.
5. Gives punishment for incorrect responses	C., M.C.
6. Provides opportunity to discover differences between correct S-R associations and other incorrect associations before making a response	P., M.C.

theory that the methods requiring an overt constructed response showed up better because of the nature of the criterion test rather than any superiority in presentation and that overt responding may not be as important in learning as some theoreticians would have us believe.

2. (a) If the mean for the P. method is significantly higher than the P. C., C., and M.C. methods there will be support for the theory that reward is not an important factor in learning paired-associates (on either one or both criterion tests).

   (b) Part (a) will also be supported if the S-R method is superior to the P.C., C., and M.C. methods.

   (c) If the means for either or both the P. and S-R methods are significantly higher than those of the P.C., C., and M.C. then support for the theory that feedback is not an important part of learning paired-associates will be lent.

3. If the mean for the P. method is significantly higher (on either or both criterion tests) than the P.C. and C. methods, then the theory that "pointing out differences before responding is better than pointing out differences after responding" will be supported.

4. If both the C. and M.C. method means show up significantly lower than all other methods, then the theory that "punishment has a dilatory effect on learning" will be supported.

5. If the means for the P.C. and C. are significantly better (on either or both tests) than all the other means then the theory that "either reward or pointing out differences or both are important in learning paired-associates will be

supported.

6. If the P.C. mean shows up significantly better than the C., the pointing out of differences will probably be the determining factor. Although, as mentioned earlier, the P.C. method probably emphasizes the reward factor more than does the C. method (this is because of not punishing, as is done in the C. method, as well as pointing out any little part of the student's response which is correct), the fact that the student does not get the word correct may be interpreted as punishment and thus even though he is told what he got right he may still feel punished.

The above suppositions or questions have been presented as if there were only one criterion testing session. It is assumed the reader can make the necessary adjustments in the conclusions to be drawn when the criterion tests, given one week after the first, are administered. (i.e. In the one case we are talking about short term performance, in the other, long term performance or retention).

The above questions are little more than guesses and will not be proven in this study. They are only offered as thoughts on "why" one thing or another should happen. The main purpose of this study was to find the best method (from among the five given) of teaching paired-associates, using only a computer to present the material to be learned. The following hypotheses were offered.

IV. HYPOTHESES TO BE TESTED

1. That there are no significant differences between the criterion score means as measured by the multiple choice test (Test 2)

and the means as measured by the constructed response test (Test 1).

2. There are no significant differences among mean scores for each of the five teaching methods as measured by both criterion tests.
3. There are no significant differences between criterion mean scores for TEST 1 at time one and time two.
4. There are no significant differences between mean scores for teaching methods for TEST 1.
5. There are no significant differences between criterion mean scores for TEST 2 at time one and time two.
6. There are no significant differences between mean scores across teaching methods for TEST 2.

CHAPTER IV

EXPERIMENTAL DESIGN

I. PROCEDURE OF THE STUDY

In order to clarify the procedure of the present study a step by step outline is presented.

1. Criteria were established for an operational definiton of learning. It was decided that amount learned per unit time would be the evaluation unit. Five levels of the teaching method factor and two levels of the test factor were selected for Analysis I. Analysis II required the five teaching levels and two time levels.
2. A teaching program was then written in Coursewriter II which incorporated the unique characteristics of the five teaching methods and the two evaluation procedures (chapter 3) (See Appendix C). The twenty paired-associates that were taught are given in Appendix D.
3. A trial group of subjects was tested on the program in order to:
    (a) Debug the program.
    (b) Establish a workable age level for the experimental subjects.
    (c) Establish time limits which would allow adequate coverage of the paired-associates to be learned.
4. Experimental subjects were solicited through playground supervisors and through the Central Volunteer Bureau in Edmonton. They were bussed to the IBM 1500 computer installation at the University of Alberta in groups of

ten. An attempt was made to distribute the students evenly among the five testing methods and two criteria tests. Subjects were randomly chosen for assignment to any particular method or test.

5. General trial runs were made in order to debug the program proper. After the technical problems were removed strategy decisions were checked out and the following conclusions made.

    (a) That 11 and 12 year old children (the originally proposed experimental group) were too slow in developing the skills needed to efficiently operate the terminal units and thus should be replaced by 12 and 14 year olds.

    (b) That the teaching time (the time students spend on each method) should be lengthened from 20 to 25 minutes in order to allow students to get through all the words in method one at least two times.

    (c) That the retesting session should be one week after the first.

Originally one hundred and twenty students were contacted and agreed to participate in the program. Of these 87 actually showed up for the first session and 68 attended both sessions. The dropouts, unfortunately, did not randomly distribute themselves over the five methods and two tests. Cell frequencies ranged from four to eleven

and this necessitated the use of an analysis program employing an unequal n's approach. (see Table I) The time needed to get through method one was underestimated and in most cases the students working on method one were unable to complete the twenty words in the time allotment. If one counts each time a word is presented, the number of words presented to individual subjects ranged from 11 to 281.

6. Each subject went through four distinct steps in his first experimental run:

   (a) an untimed introduction to the computer terminal where the student learned to use the terminal. Each student spent as much time as he wished on this section and proceeded only when he felt he was ready.

   (b) a section where all the twenty paired-associates to be learned were presented, each for a period of five seconds. (Appendix D)

   (c) a section where the student was taught the associates by one of the five different methods. He looped the twenty pairs for a period of twenty five minutes.

   (d) a section in which the subject was examined by one of the two criterion tests. (See Appendix C)

TABLE I

NUMBER OF SUBJECTS IN

EACH CONDITION

METHOD	TEST 1			TEST 2		
	TIME ONE	TIME TWO	% RETURN	TIME ONE	TIME TWO	% RETURN
1	7	5	71	8	7	88
2	8	8	100	9	7	77
3	8	5	63	12	11	92
4	7	6	86	10	10	100
5	8	4	50	10	6	60
TOTAL	38	28	73	49	41	83

7. One week after the first session the students were brought back for a second testing period on the same criterion test to which they had previously been exposed. This second session was also conducted entirely on the IBM 1500 system. (Appendix B)

II. ANALYSIS OF DATA

Although one may consider this study to have three factors (method, type of test, time of testing) only two way analysis of variance tests were conducted since the three way interaction was not of interest.

A. ANALYSIS I

In analysis one the teaching factor and the "type-of-test" factor were used. ANOV 20 (D.E.R.S. 1968) was used. A two factor analysis with unequal n's and independent samples was performed by this program. Because of the dropouts only the first testing session results were used. Also, because the dropouts did not evenly distribute themselves it was decided that a posteriori tests on the teaching method means were not valid.

B. ANALYSIS II

The second analysis was performed on the teaching method factor and the time factor. The University of Alberta's ANOV 23 (D.E.R.S. 1968) was used. It employs a two factor design with repeated measures and unequal n's. This analysis was used on both the multiple choice and the constructed response tests.

C. ANALYSIS III

A group of planned comparisons using the methods outlined by Winer (1962) were performed. These comparisons were designed in

accordance with the "Questions" asked in the previous chapter. The comparison weights used to test each question together with the number of the question being tested are given in Table VI.

The formula used to calculate the F ratios is given below.

$$F = \frac{(\Sigma C_k \bar{A}_k)^2}{\sum \frac{C_k^2}{n_k}}{MS_{\text{within cell}}}$$

C_k = contrast weight of level k

$\bar{A}_k$ = mean of the scores in level k

Comparisons were conducted on simple effects rather than main effects. The denominator used would be the same as that used to test the main effects on the analysis of variance. The critical value used was $4F^4_{df}$ where df is the number of degrees of freedom for MS within.

D. ANALYSIS IV

In order to determine possible relationships among students' ages, intelligence and achievement, and in order to see if the more times a student is presented with a paired stimulus the more likely he is to learn the association, correlation coefficients were calculated among the following variables:

1. First testing session scores (both test 1 and test 2).
2. Second testing session scores (both test 1 and test 2).
3. Time to complete section on "how to use terminal".
4. Number of times student was exposed to pairs.
5. Age of student.

CHAPTER V

RESULTS AND DISCUSSION

I. ANALYSES

A. ANALYSIS I

The results of Analysis I are summarized in Table II. It indicates the test-type main effects to be significant at less than the .001 level and thus forces rejection of hypothesis one that there will be no differences between the types of criterion tests used. This of course was not unexpected. There is an obvious score advantage to using a multiple choice criterion test. The cell means are shown in Figure 4.

Method Main effects proved to be significantly different at the point .002 level. These effects are explored more fully in Analysis II. The main purpose for Analysis I was to check for an interaction between methods and test type. The results indicated that hypothesis of no interaction was not rejected.

B. ANALYSIS II

A summary of Analysis II is given in Tables III and IV. The average scores (expressed as percents) for the five methods and two tests at time 1 are shown in Table V. As can be seen from Table III a significant difference was registered in the "time" main effects (as measured by TEST 1) thus rejecting hypothesis 3. Both the methods main effects and the interaction failed to reach the acceptable level of significance thus hypothesis 4 was not

TABLE II

TEST (1 & 2)

SUMMARY OF ANALYSIS OF VARIANCE

SOURCE	SS	df	MS	F	P
METHODS (MAIN EFFECTS)	9339.5	4	2334.8	4.603*	.002
TESTS (MAIN EFFECTS)	11147.1	1	11147.1	21.974*	.000
INTERACTION	1990.3	4	498.0	.981	.423
ERROR	39061.0	77	507.0		

* .1 level of significance accepted for this study.

Figure 4

MEANS FOR TEST 1 AND TEST 2

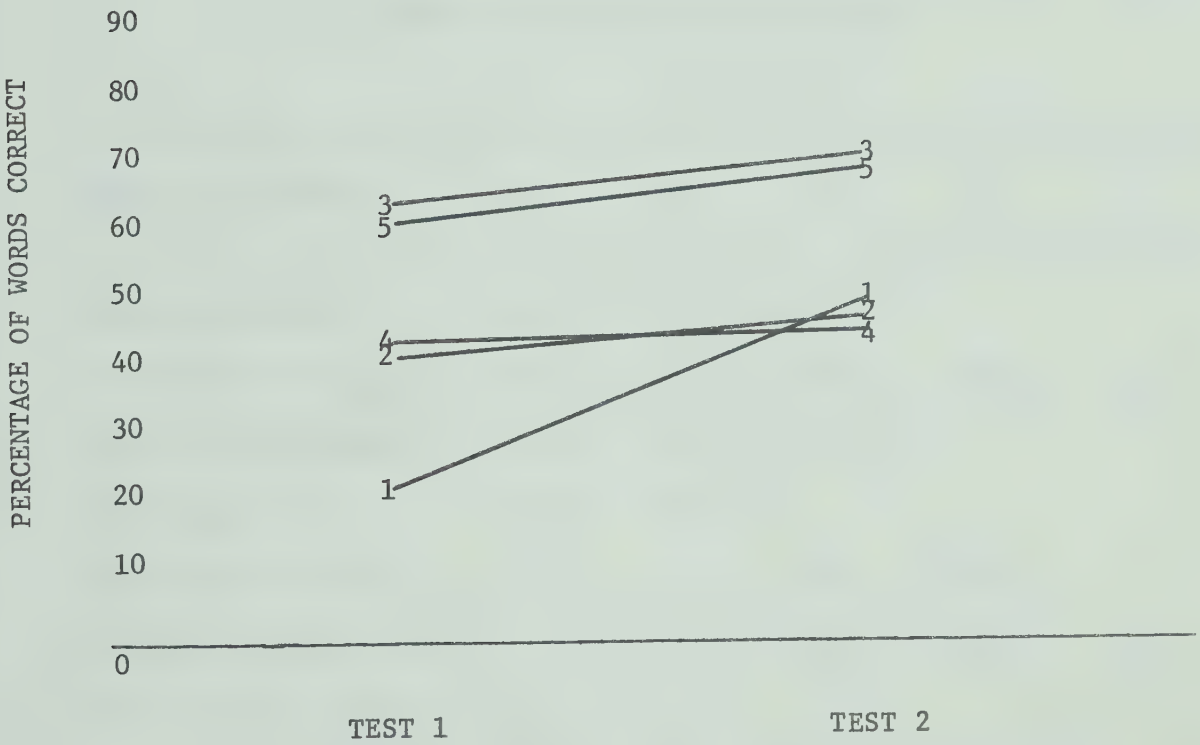


TABLE III

TEST 1

(CONSTRUCTED RESPONSE)

SUMMARY OF ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	SS	df	MS	F	P
BETWEEN SUBJECTS	33403	26	1		
METHODS (MAIN EFFECTS)	6283	4	1570	1.253	.318
SUBJECTS WITHIN GROUPS	27572	22	1253		
WITHIN SUBJECTS	2650	27			
TIME (MAIN EFFECTS)	748	1	748	10.825*	.003
METHOD-TIME INTERACTION	473	4	118	1.714	.182
TIME x SUBJECT WITHIN GROUPS	1520	22	69		

* .1 level of significance accepted for this study.

TABLE IV

TEST 2

(MULTIPLE CHOICE)

SUMMARY OF ANALYSIS OF VARIANCE

SOURCE OF VARIATION	SS	df	MS	F	P
BETWEEN SUBJECTS	31556	40			
METHODS (MAIN EFFECTS)	4746	4	11867	1.648	.183
SUBJECTS WITHIN GROUPS	25916	36	719		
WITHIN SUBJECTS	4050	41			
TIME (MAIN EFFECTS)	3	1	3	.039	.844
TIME x METHOD INTERACTION	393	1	98	.963	.439
TIME x SUBJECT WITHIN GROUPS	3675	36	102		

TABLE V

AVERAGE PERCENT CORRECT ANSWERS

FOR FIVE METHODS
(Time 1)

	METHOD OF TEACHING				
CRITERION TEST	M1	M2	M3	M4	M5
CONSTRUCTED RESPONSE	23.00	38.50	53.50	40.90	51.90
MULTIPLE CHOICE	67.80	65.40	78.60	57.80	77.50

rejected.

Since the time main effects, methods main effects and interaction effects were all non-significant for TEST 2 both hypotheses 5 and 6 were not rejected.

C. ANALYSIS III

Table VI summarizes the results of the comparisons made among the various combinations of teaching method and testing method at time 1. None of the comparisons reached significance for Test 1 or Test 2.

D. ANALYSIS IV

Correlation coefficients are reported in Table VII and show a significant negative correlation between the criterion tests and the speed with which the student went through the teaching section on how to use the terminal. All other coefficients turned out to be non-significant with the exception of the correlation between the first testing session and the second testing session.

II. INTERPRETATION OF RESULTS

Analyses of variance on TEST 1 and TEST 2 show conflicting results on the main effects of the time factor. One might expect that with time it is natural for students to forget and that both tests should show significant differences between the time levels. However, the two tests were different in a rather fundamental manner. The constructed response test (TEST 1) was a recall test, the student had to fabricate his response entirely from memory. The multiple choice test on the other hand, is a recognition test - all the subject had to do was recognize the response.

TABLE VI

SCHEFFÉ CONTRASTS OF CELL MEANS
at Time 1

COMPARISON NUMBER	QUESTION TESTED	CONTRAST WEIGHTS M1	M2	M3	M4	M5	Test 1 ANALYSIS	Test 2 ANALYSIS
1		-4	1	1	1	1	3.47	.06
2		1	-4	1	1	1	.12	.40
3	2(a)	1	1	-4	1	1	1.43	2.91
4		1	1	1	-4	1	.02	4.38
5	1a,1b,2b	1	1	1	1	-4	.90	1.44
6	2c	1	1	-1	1/2 1	-1 1/2	3.25	5.34
7	3	-1	-1	2	0	0	2.89	2.45
8	5	-1 1/2	-1 1/2	1	1	1	3.36	.55
9	6	1	-1	0	0	0	1.12	.06
10	4	1	-1 1/2	1	-1 1/2	1	.10	4.50

TEST	df for denominator	CRITICAL F VALUE @=.10	@=.05	@=.01
TEST 1	22	8.88	11.28	17.24
TEST 2	36	8.36	10.44	15.32
SYMBOL USED IN TABLE VI		*	**	***

TABLE VII

INTERCORRELATIONS

VARIABLE	1	2	3	4	5
1. 1st. testing	1.00	.86*	-.48*	.20	.20
2. 2nd. testing		1.00	-.45*	.10	.13
3. Prelim. time			1.00	-.29	-.19
4. No. of words				1.00	.04
5. Age of student					1.00

N = 68 *critical r = .307 α = .01

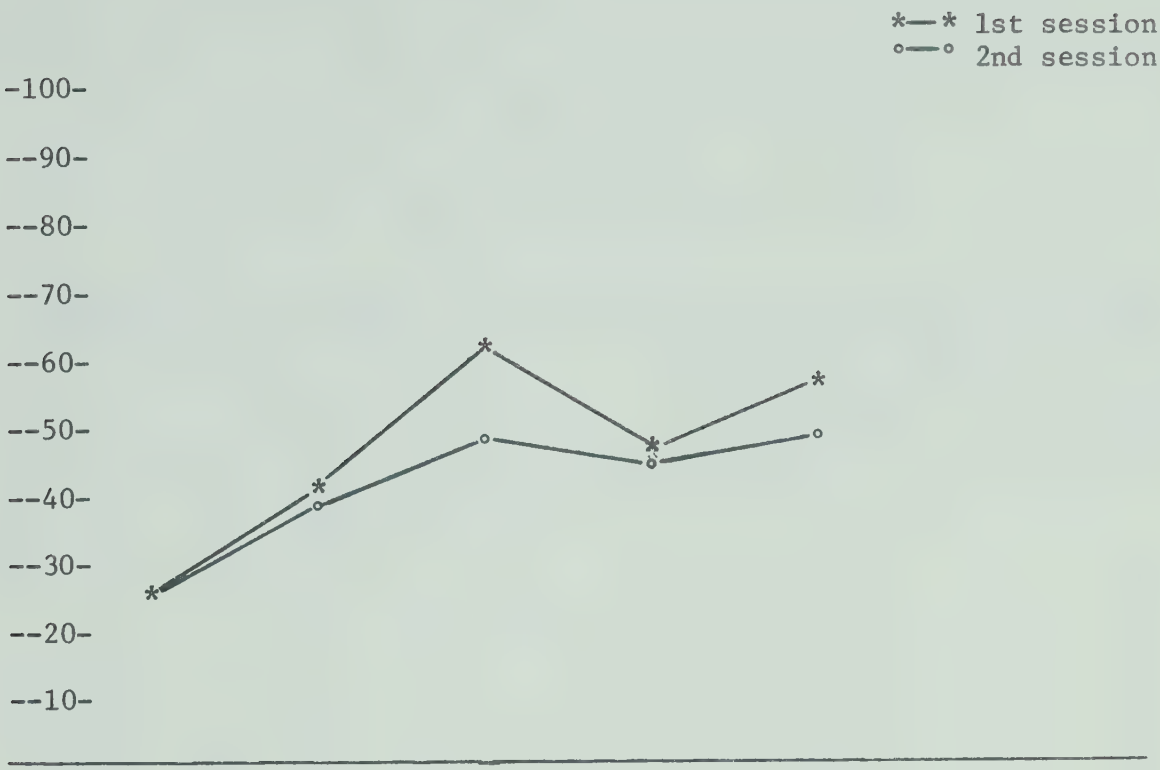
The lack of interaction between the two tests (Analysis I) would tend to indicate that the major difference between how the various groups reacted to these tests is one of degree. It appears that one retains the ability to recognize much longer than one retains the ability to recall.

Analysis II indicated that neither criterion test was able to detect significant differences among the teaching methods. If the plots of the means for each of the analyses in Figure 5 are considered it can be seen that methods 3 and 5 are consistently higher than the other methods on the first testing. Perhaps, had the N been larger, the analysis of variance on TEST 1 and/or TEST 2 would have shown significant simple effects for the first testing sessions. Observation of Figure 5 reveals that the two best methods (3 and 5) on the initial testing session were also the two methods which resulted in the greatest drop in retention over time for TEST 1. Nevertheless none of these findings reached statistical significance.

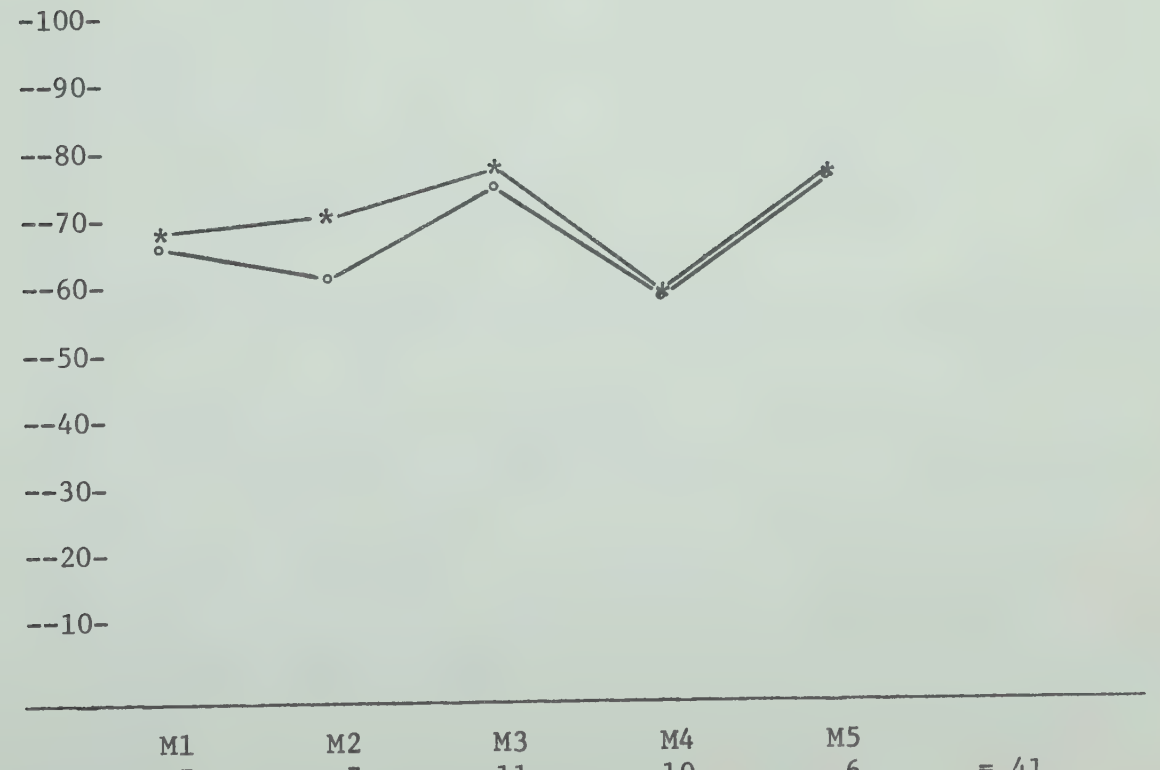
In order to get a better idea of the effects of time on the teaching methods the comparisons of Table VI were performed again on the simple main effects for TEST 1. The results of those comparisons are reported in Table VIII. From Table VIII it can be shown that the F-ratios showing the differences of M3 and M5 (comparisons 3 and 5) from the other methods, although not significant, do decrease somewhat from the first to the second testing session. The comparison of the difference between the combination of methods 3 and 5 and the other methods also dropped. One could speculate that if the time interval were extended (or that if more

FIGURE 5

MEANS vs. METHOD BY TESTING SESSION



(a) TEST 1



(b) TEST 2

TABLE VIII

COMPARISONS ON TEST 1

#	CONTRAST WEIGHTS M1	M2	M3	M4	M5	TEST 1 1st session F	TEST 1 2nd session F
1	-4	1	1	1	1	4.35	2.37
2	1	-4	1	1	1	.13	.09
3	1	1	-4	1	1	2.34	.65
4	1	1	1	-4	1	.22	.10
5	1	1	1	1	-4	1.44	.42
6	1	1	-1 1/2	1	-1 1/2	5.24	1.49
7	1	1	-2	0	0	4.13	1.62
8	-1 1/2	-1 1/2	1	1	1	4.10	2.34
9	1	-1	0	0	0	1.45	.75
10	1	-1 1/2	1	-1 1/2	1	.42	.01

F_{crit} α = .1 = 8.36 1st session

F_{crit} = .1 = 8.88 2nd session

levels of the time factor were added) the drop in M3 and M5 would have been even more significant and perhaps methods two or four would have been shown as superior. Since method one had the least drop between testing sessions it may have ended up on top had the time interval been extended far enough. However, a floor effect may be responsible for the small change in the scores for method 1. Perhaps it would have improved the design of the study had a group of students been given the tests immediately after being presented with the initial twenty words. The absolute effect of the teaching methods could then have been estimated.

None of the contrasts listed in Tables VI and VIII was significant. However figure 5 indicates that method 3 was higher than all other methods with the possible exception of method 5. In view of the large drop off in attendance for method 5, one would suspect that method 3 may be superior to the others.

It is interesting to note that in both TEST 1 and TEST 2 the methods most like the criterion tests - method 1 for TEST 1 and method 4 for TEST 2 - resulted in the lowest means on those tests.

Although nothing definite could be concluded from the above mentioned contrasts it should be pointed out that the procedures which traditionally have been considered important in learning (i.e. feedback, overt responding and reinforcement) and which were being tested for impact on criterion scores, (being tested in the sense that methods containing these characteristics were contrasted with those which did not) failed to show a significant effect on the subjects as indicated by their criterion scores.

CHAPTER VI

SUMMARY, DISCUSSION, CONCLUSIONS, LIMITATIONS AND IMPLICATIONS FOR FURTHER RESEARCH

I. SUMMARY

The purpose of this study was to test the effectiveness of five different methods of teaching paired-associates on a computerized teaching machine. Effectiveness was measured by two different criterion tests - a recall test and a recognition test. Each of these criterion tests was used to measure the effectiveness of the methods over two different time periods - immediately after the teaching sessions and one week after the teaching session. The criterion used was amount learned per unit time.

Samples of 12 - 14 year olds were randomly assigned to each of the teaching methods and 2 criterion tests.

Six hypotheses were proposed for testing and are listed below:

1. That there is no significant difference between the criterion score means as measured by the multiple choice test and the means as measured by the constructed response test - rejected.
2. That there are no differences among mean scores for each of the five teaching methods as measured by a combination of both the criterion tests (Teaching methods main effects.) - rejected.
3. That there are no significant differences between the criterion mean scores for TEST 1 at time one and time two. (Time main effects for TEST 1) - rejected.

4. That there are no significant differences among mean scores across teaching methods for TEST 1 (Methods main effects for TEST 1) - not rejected.
5. That there are no significant differences between criterion mean scores for TEST 2 at time one and time two (Time main effects TEST 2) - not rejected.
6. That there are no significant differences among mean scores across teaching methods for TEST 2 (Methods main effects for TEST 2) - not rejected.

Although hypotheses four and six were not rejected, the lack of interaction between methods and testing procedures and the rejection of hypothesis two, would, upon inspection of the means in Table V and inspection of the F-ratios in Table VI, tend to favour Method Three, the Prompt Method. This is on the basis of testing at time one. There was also an indication that this same method resulted in the greatest loss in retention over time. The lack of interaction when testing hypotheses one and two indicated that the teaching methods did not act differentially on recall and recognition. Hypothesis five not being rejected indicated that the ability to recognize is retained over longer periods of time than is the ability to recall. There was also some indication that reinforcement, feedback, or even overt responding does not increase a person's rate of learning of paired-associates.

II. DISCUSSION

The fact that the two methods which supplied no feedback

(and in one case did not even require an overt response) seemed to produce the better results appears contrary to common opinion. This finding was not significant and may have been due to sample variation or may have been a result of the criterion chosen for this experiment - amount learned per unit time. Most paired-associate experiments use amount learned per presentation as the criterion, with little or no recognition being given to the amount of time taken. This criterion thus allowed the students in each group to view the pairs of differing number of times. That is, the number of times a student actually viewed one of the pairs was quite different for each of the methods used. Table IX indicates that methods three and five had the highest average number of words looked at. Since there were twenty pairs in all, it can be seen that many students in method one did not see the entire set of tasks.

A one way analysis of variance performed on the number of words viewed gave a highly significant F-ratio. When a contrast between the average of methods three and five and the average of the other measures was performed an F-ratio of fifty was recorded.

TABLE IX

MEAN NUMBER OF WORDS LOOKED AT

M1	M2	M3	M4	M5
15.25	33.75	59.40	43.12	165.00

These results would seem to indicate that the greater the number of

times a person views the paired-associates the higher would be his criterion score. However, the correlation coefficient between the number of words looked at and the score on the first criterion test turned out to be .20 and not significant. This would tend to indicate that something in these methods, other than the number of times a student views the pairs, was contributing to the superiority of the Prompt and S-R methods. It is noted from Table I that method 5, which was probably the most boring of the five methods tested, had the lowest return rate for the second testing session. Even though a method may produce good results initially as did this method, one must consider the motivational value of any technique finally decided upon.

III. CONCLUSIONS

The results of this experiment, though not significant, would tend to indicate that the Prompt method of teaching paired-associates is the most effective, per unit of time spent learning, when one considers short term effects. If long term effects or retention are considered in relation to recall tasks, there appears to be little differential effect among the five methods tested. Recognition tasks on the other hand tend to remain more consistent over time and thus the Prompt method would be considered superior for this type of task also. (at least for short term retention tasks - i. e. one or two weeks.)

IV. IMPLICATIONS FOR C.A.I.

Keeping in mind that significance was not reached for any particular teaching method over either of the criterion tests taken individually but, that the methods main effect over tests was recorded as significant and that the highest mean recorded was for the Prompt method - one might say that at this point in time a Prompt approach to C.A.I. should be considered. Admitting that differences exist

between the learning of paired-associate and the higher order forms of learning, one may speculate as to how a "Prompt" approach to learning may be applied to a visual presentation on the C.R.T. The text of a lesson could be broken down according to significant ideas or concepts which are to be conveyed to the learner. These ideas would have to be small enough to be presented on less than about two-thirds of the C.R.T. - leaving one-third for the presentation of a question related to the textual presentation. The question would be phrased in such a way that it would focus the attention of the subject on the main idea being presented in the text. After responding the correct answer may or may not be presented to the subject.

An alternate procedure useful for diagrams and/or text which cannot be presented in two-thirds of the screen would be to display the textual material on the film projector and use the C.R.T. exclusively for questions about that material. The function of such a procedure, as suggested by Cook and Spitzer (1960), seems to be to force the student's attention on the significant aspects of what he has just read. When a subject is novel a student has little information upon which to base his decisions about what is or is not important and could very easily skim past significant points which would be needed for understanding of future presentations.

V. LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

This study was conducted using paired-associates. The extent to which one can generalize from the learning of paired-associates to the learning of higher order concepts is not entirely

understood. Even though methods three and five seem to work for the memorizing of pairs they may be completely useless when higher order learning is involved. An experiment employing the basic ideas outlined for each of the methods mentioned above and attempting to teach higher order concepts would thus be very desirable.

Only two levels of the time factor were used. An indication that the initial effects of methods three and five are lost rather quickly was made earlier. The drop in methods three and five over one week brought their level down to that of the other methods thus forcing a conclusion that even over time these methods were at least as good as the others. However, had there been more levels of the time factor, tests for trend and other analyses may have indicated that over time the Prompt and S-R methods would in fact produce inferior results to one of the other methods. A study which extends the time levels may thus reveal important data relevant to the long term effects of different teaching methods.

The criterion used for this study was number of associates learned per unit time. This criterion was chosen because, in the opinion of the author, it represents what in fact, if not in theory, is being emphasized in schools today. The lock-step method of advancing students emphasizes that a certain amount of material must be covered in a specified amount of time. This method also neccesitates the criterion measure be given relatively soon after the teaching sessions. This then accounts for the greater emphasis given to the first criterion tests in the write up of this document. It is recognized, however, that other bases for criterion measures

may be used which could be defended as well and perhaps better than those used in this project. The number of presentations of the associates could have been held constant and learning per unit number of presentations been the criterion. The student could have been allowed the choice of how long he would spend on the teaching method - he would have been instructed to stay on the teaching section of the program until he felt he knew the material. Initiation of the branch to the criterion test would be made by him. This method would be closer to the ideal of individualized instruction which is advanced by proponents of C.A.I. and possibly would have been a better criterion measure for this particular project than the one finally decided upon. It certainly approximates the real study situation where the determination and will-power of the student are real variables which enter into his actual achievement.

At the time of the initiation of this study there were only two aspects of the IBM 1500 instruction machine which were operable - the C.R.T. and the film slide projector. Because of the need to limit a project of this sort to a manageable size only a small facet of the use of the C.R.T. was investigated in terms of the teaching methods which are possible on this machine. The use of graphics, (picture displayed on the C.R.T.) the use of the slide projector, the combined use of the projector and the C.R.T. are only a few of the areas which may be explored further. Now, a computer controlled audio unit is available on the 1500 and opens up a tremendous new field for investigation in learning. How does an auditory stimulus in paired-associate learning relate to visual stimuli? Comparisons of visual methods, audio methods, and audio-

visual methods of teaching can now be made and controlled to a degree never before possible.

As mentioned in the introduction to this study it is the belief of this writer that the computer has a potential in the field of education and psychology which is limited only by the imagination of man. A popular argument against the use of a "machine" in teaching is that it is dehumanizing and will make robots of those taught by it. The experience of this author during the course of the past three years has led him to believe otherwise. It is his opinion that the computer is much less cold and inhuman than any textbook a student has ever been forced to interact with and is much more capable of transmitting the personality of the programmer than is any such textbook. Students have been observed interacting and gaining self esteem to a degree very comparable and perhaps greater than that which is possible in the present teaching situation in our schools.

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BIBLIOGRAPHY

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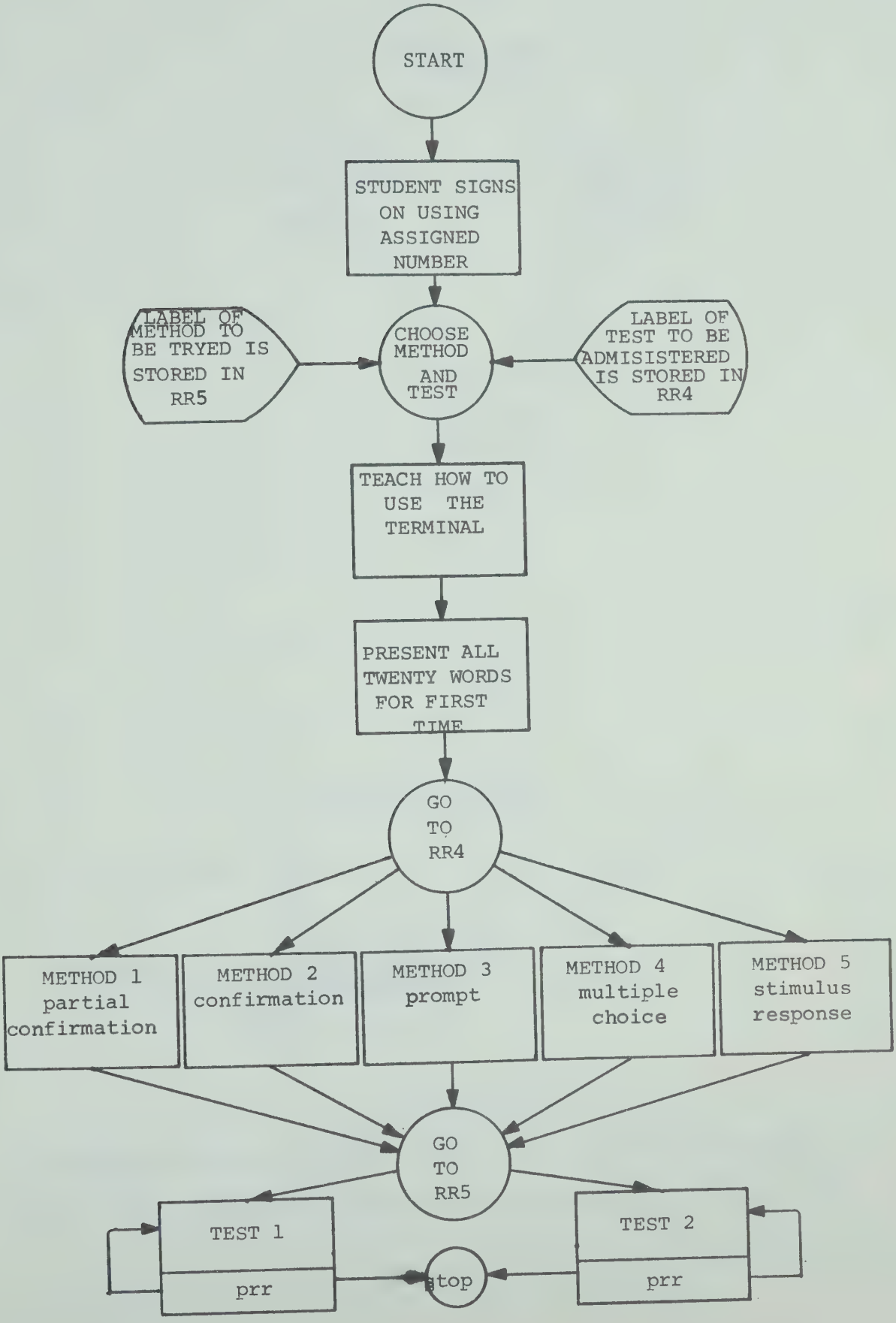
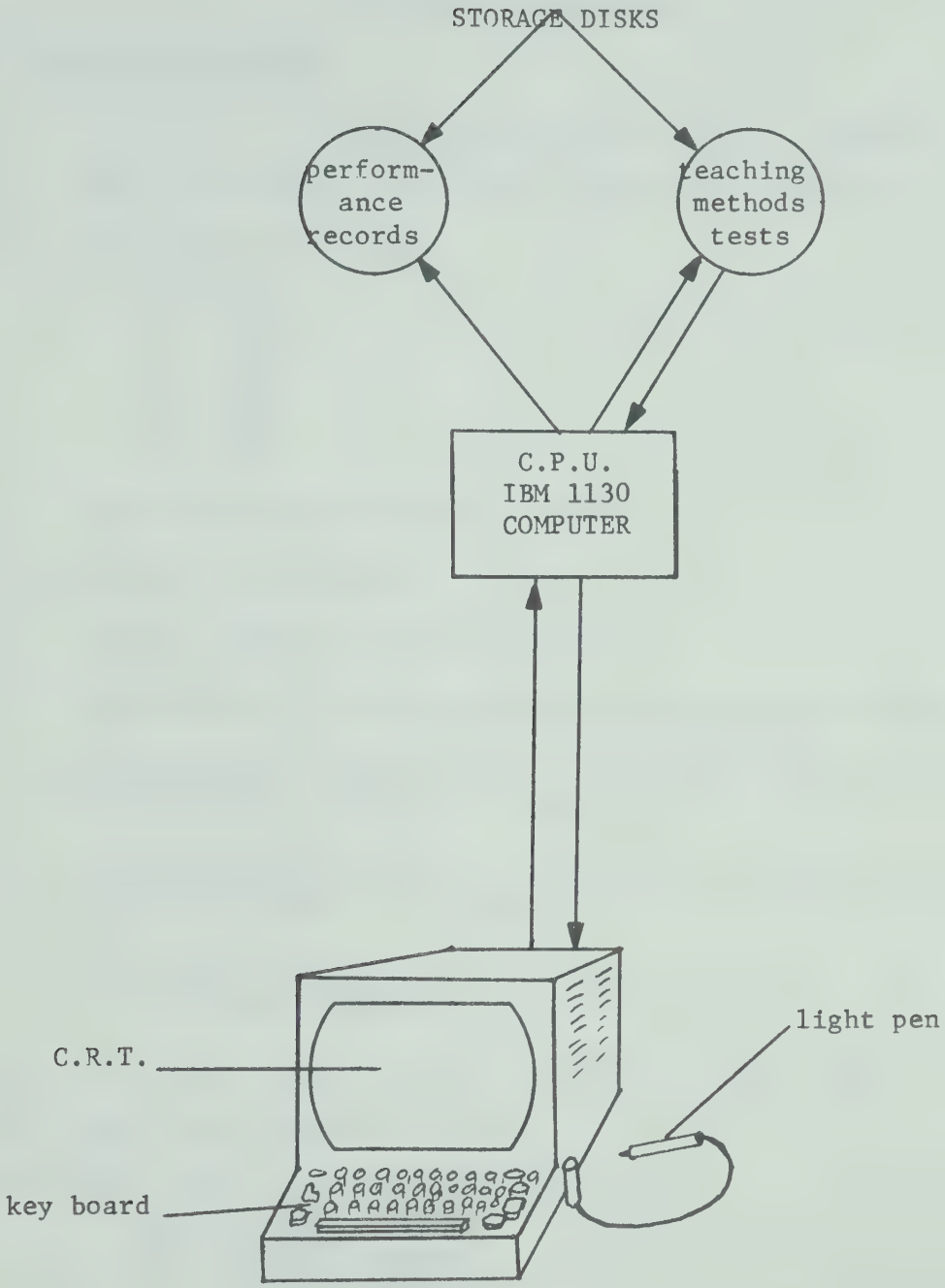
APPENDICES


START
STUDENT SIGNS ON USING ASSIGNED NUMBER
LABEL OF METHOD TO BE TRYED IS STORED IN RR5
CHOOSE METHOD AND TEST
LABEL OF TEST TO BE ADMISISTERED IS STORED IN RR4
TEACH HOW TO USE THE TERMINAL
PRESENT ALL TWENTY WORDS FOR FIRST TIME
GO TO RR4
METHOD 1 partial confirmation
METHOD 2 confirmation
METHOD 3 prompt
METHOD 4 multiple choice
METHOD 5 stimulus response
GO TO RR5
TEST 1
prr
stop
TEST 2
prr



THE MACHINE

The terminals used by students consist of a C.R.T. for displaying of text, and a keyboard and light pen for the student to respond with.

DOCUMENTATION FOR TRY

A. Operator Information

1. The name of the course is TRY and it has two segments.

2. Only the standard and reverse dictionaries are used.

3. The functions used are:
   (a) mv
   (b) ed
   (c) keyl
   (d) mc
   (e) es
   (f) sm

4. Only one macro is called - - DU007.

5. No films are required.

6. No audio tapes are required.

7. The estimated time for completion of the program is 50 minutes.

8. All important response times are specified (when an ep is used as a pae the system time is used).

9. This program should be self-explanatory. A section on how to use the terminals is included).

10. The student will sign on as follows:
    on latin (student no.)

11. No one should be required to supervise while running this program.

12. There are no proctor messages.

13. Performance recording will consist of
    (a) response times
    (b) counter values
    (c) text of responses

14. The use of this program shall be restricted to those students whose names appear on a list which will be provided by the author.

B. Programmer Information

1. For flowchart see Appendix A.

2. No new macros were developed for this course. The one macro used, DU007, is taken from the macro library.

3. All six buffers are used.

4. All thirty counters are used.

5. Switches zero through S22 are used.

6. All six return registers are used.

7. The functions used are
   (a) ed
   (b) mc
   (c) keyl
   (d) mc
   (e) es
   (f) sm
   (g) mv

8. There are no proctor messages.

9. Response times are all specified.

10. Where ZZ identifiers are used with the ep's no performance recording is done.

11. No dictionary and/or graphic sets are used other than the standard and reverse dictionaries.

12. No projector or audio tapes are used.

13. Special Features

   (a) Three subroutines were developed in order to cut down on the volume of the program. The are:

Macro 1 - This subroutine allows a multiple choice test to be presented and marked with only the loading of buffers and 3 counters required of the author. If a different question is needed for another pass of the program, all or part of the text of the question may be changed by having the subroutine jump to a label at which the required instructions are located (see Appendix B). The subroutine will branch to the label, present the text of the question, then branch back to the routine and proceed with the rest of the processing. This subroutine is used with Test 2.

Macro 2 - This subroutine allows a student's answers to be analysed and partially fed back with dashes replacing mistakes in his response. It is used with method one, the Partial Confirmation Method.

Macro 3 - This subroutine allows an author's text to be presented to the student in a multiple choice format. That is, a question may be asked of a student and several alternatives presented to him. If he points to the correct alternative he is rewarded. If he points

to an incorrect alternative it is erased and the student is requested to try again. This subroutine is used in Method four, the Multiple Choice Method.

(b) A method for randomly selecting methods and tests was developed. Based on his student's number a subject is randomly assigned to one of the five treatments and one of the two criterion tests.

C. Information for the Educator

1. The purpose of TRY is to compare five different methods of teaching paired associates and two different criterion tests.

2. The five methods of teaching are:

(a) Partial Confirmation - that part of the students' answer which is correct is fed back with hyphens replacing the incorrect characters.

(b) Confirmation - If students response is correct the word "RIGHT" is flashed on the screen. If it is incorrect the correct word is shown.

(c) Prompt - The pair to be associated are presented in the context of a paragraph. A question is then asked and the correct answer must be determined by searching the paragraph.

(d) Multiple Choice - One of the pair of words to be associated is shown and the other word is presented as one of six alternatives. The student is required to find the other word.

(e) Stimulus-Response - The two words to be associated are presented together. The student presses the space bar to get another pair. After going through one of the five treatments listed above the student will be given one of the following criterion tests.

(a) A Constructed Response Test - a test where the student is required to type out the correct answer from memory.

(b) A Multiple Choice Test - a test where the student is required to point to one of six alternative answers presented to him.

3. The major source for information on methods (b) (c) (d) and (e) above were the writings of the early programmed learning specialists. Method (a) above came from the writing in C.A.I. and is a uniquely computer based system. (i.e. it could not be approximated except on a computer. All the others had to be tried in pro-

grammed text books in the past).

4. The material in this program was designed for the grade six level.

5. Execution time is about 50 minutes.

6. This program is not really a course in the sense that it is trying to teach a lesson. It is designed as part of an experimental project to test different methods of teaching on the IBM 1500.

7. No films or audio tapes are used.

8. Keyboard responses are required exclusively in the

   multiple choice and
   test two.

9. The student needs to know nothing about the operation of the terminal to take the course.

10. A teacher or proctor is not needed for execution of the program.

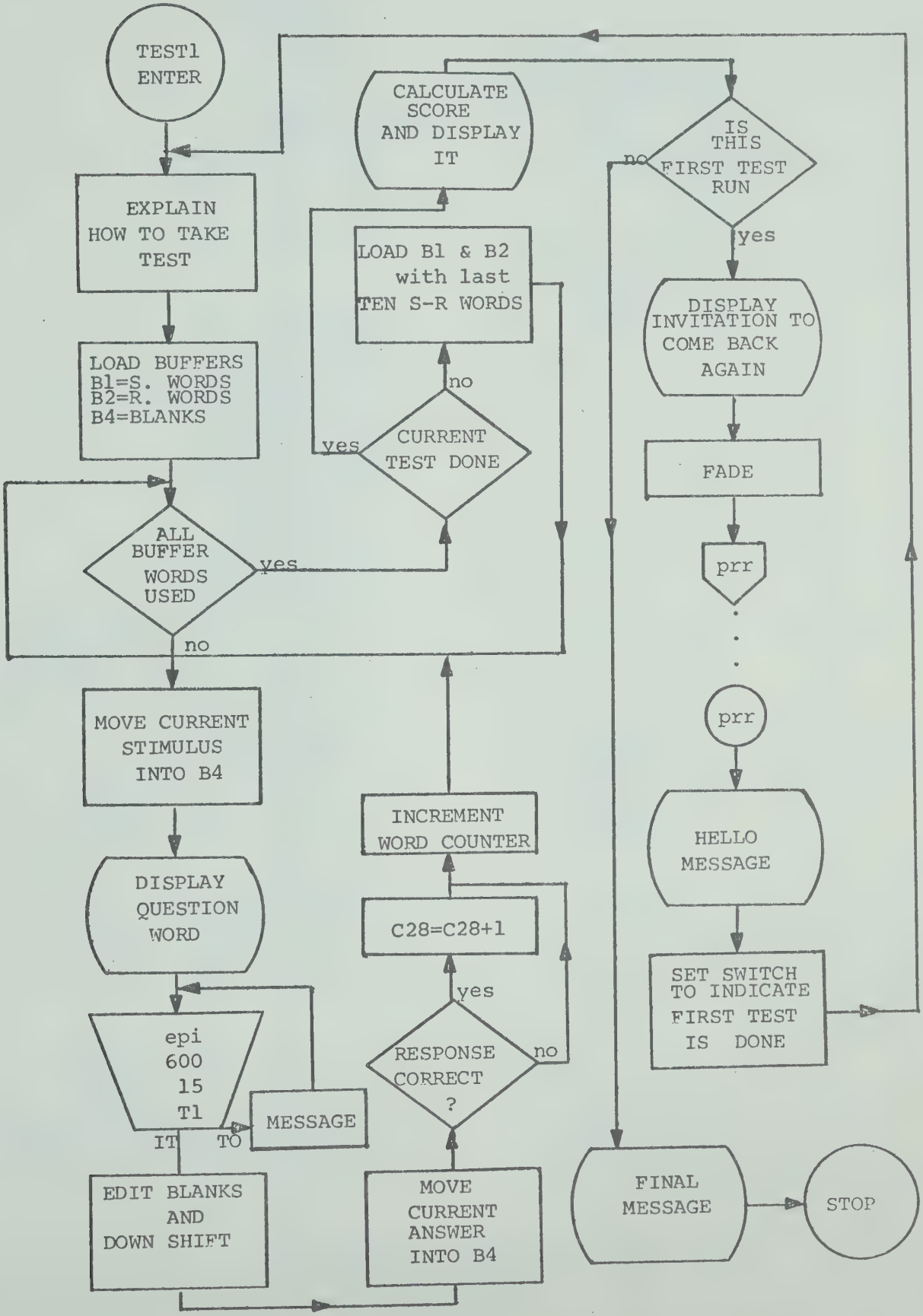
11. Performance recording is made of:
    (a) the number of correct responses made during the execution of a method.
    (b) the response times for each ep.
    (c) the score made on each test.

12. No auxiliary materials are required.

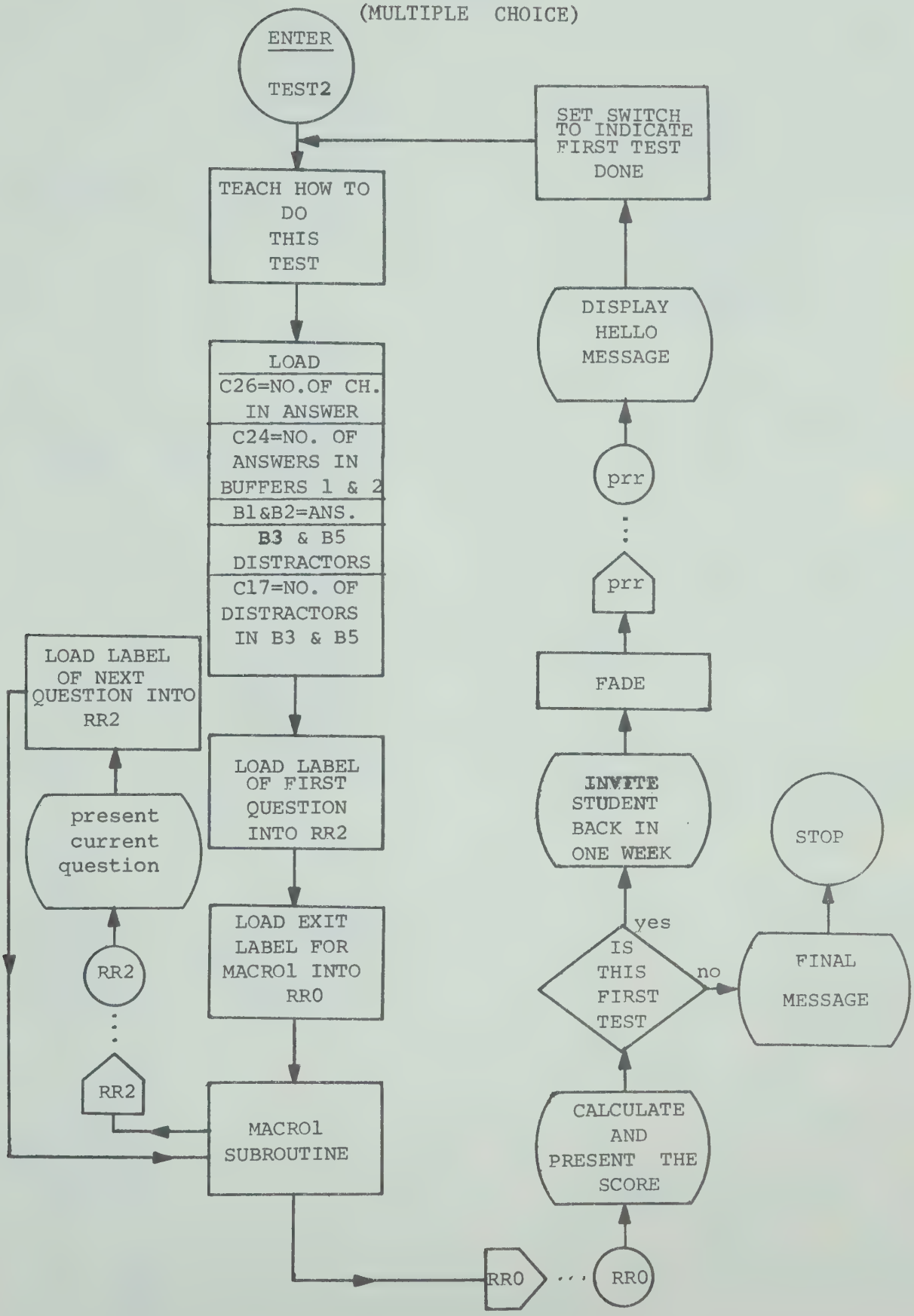
13. The programmer and author of this course is

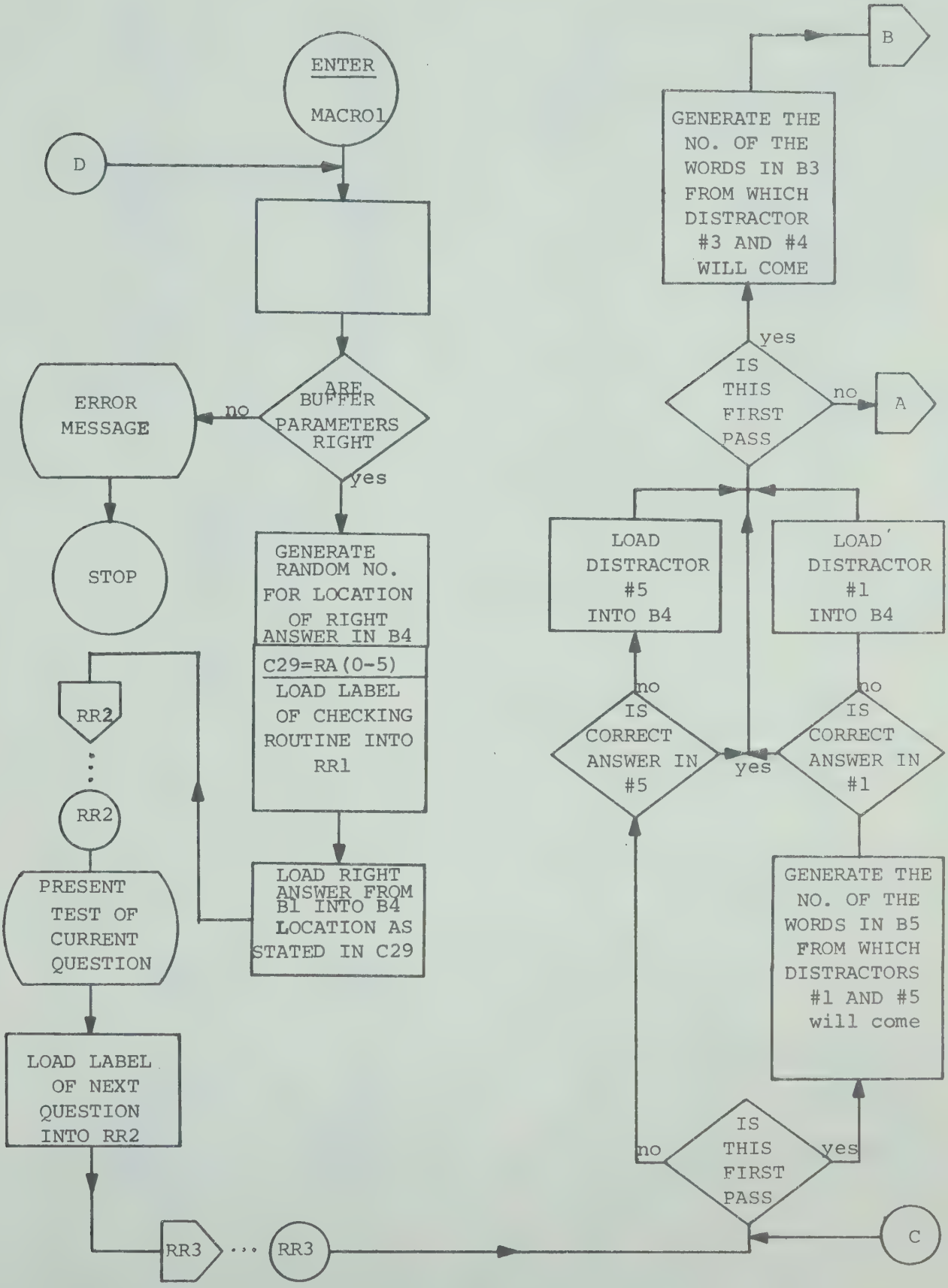
Donald W. Price
4719 - 105 A Avenue
Edmonton 80, Alberta
466 - 7422

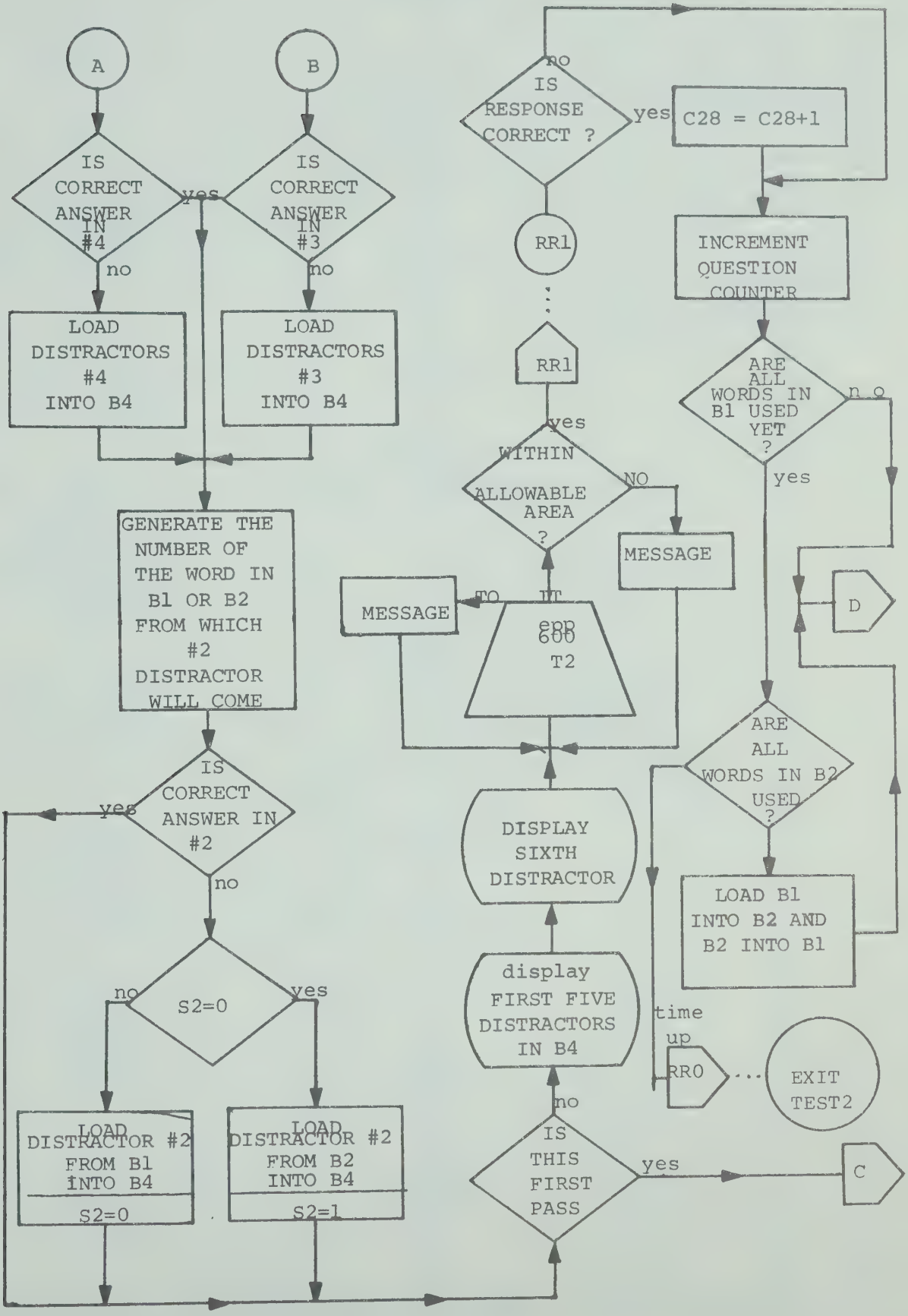
TEST ONE
(CONSTRUCTED RESPONSE)



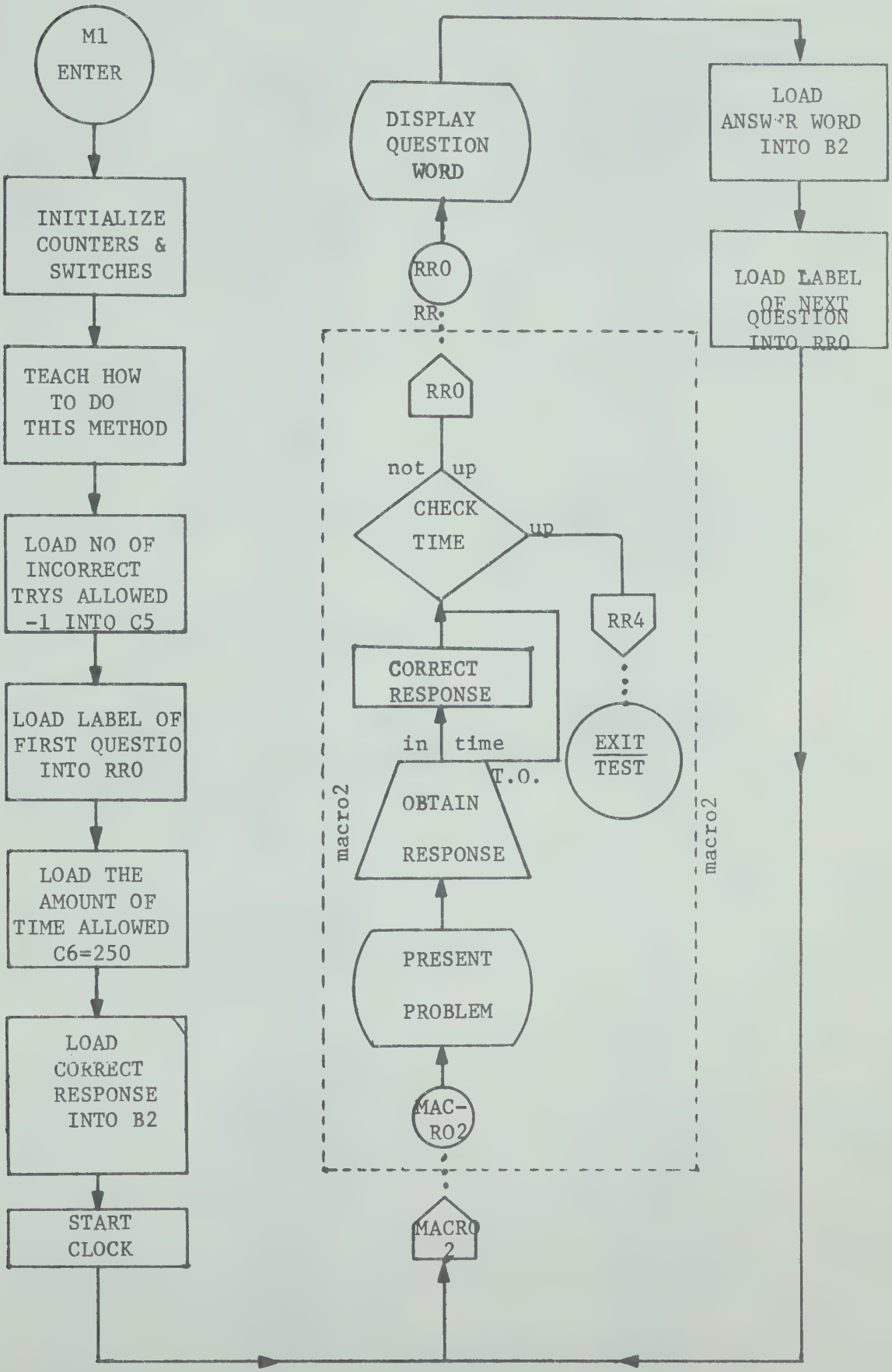
TEST TWO
(MULTIPLE CHOICE)

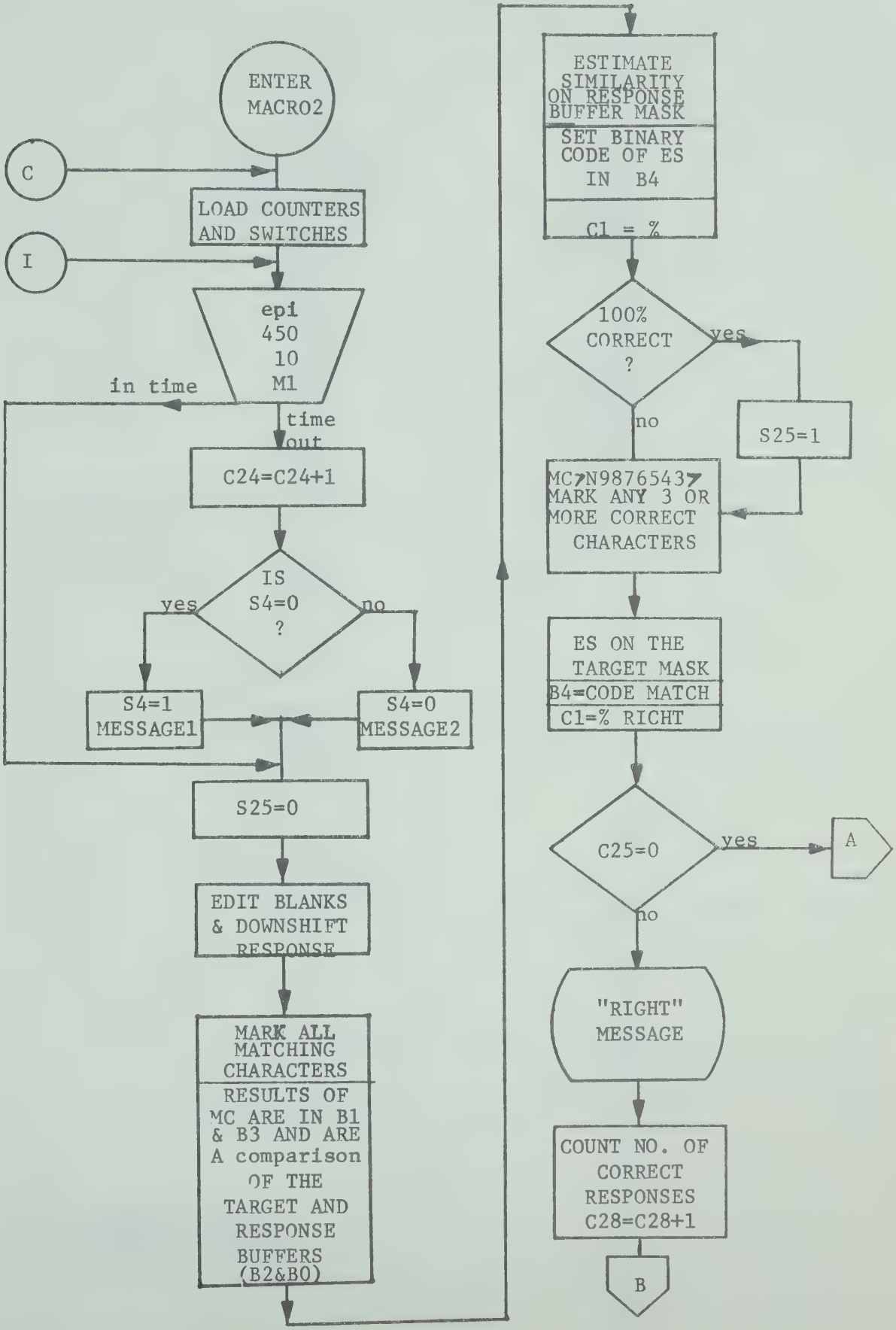


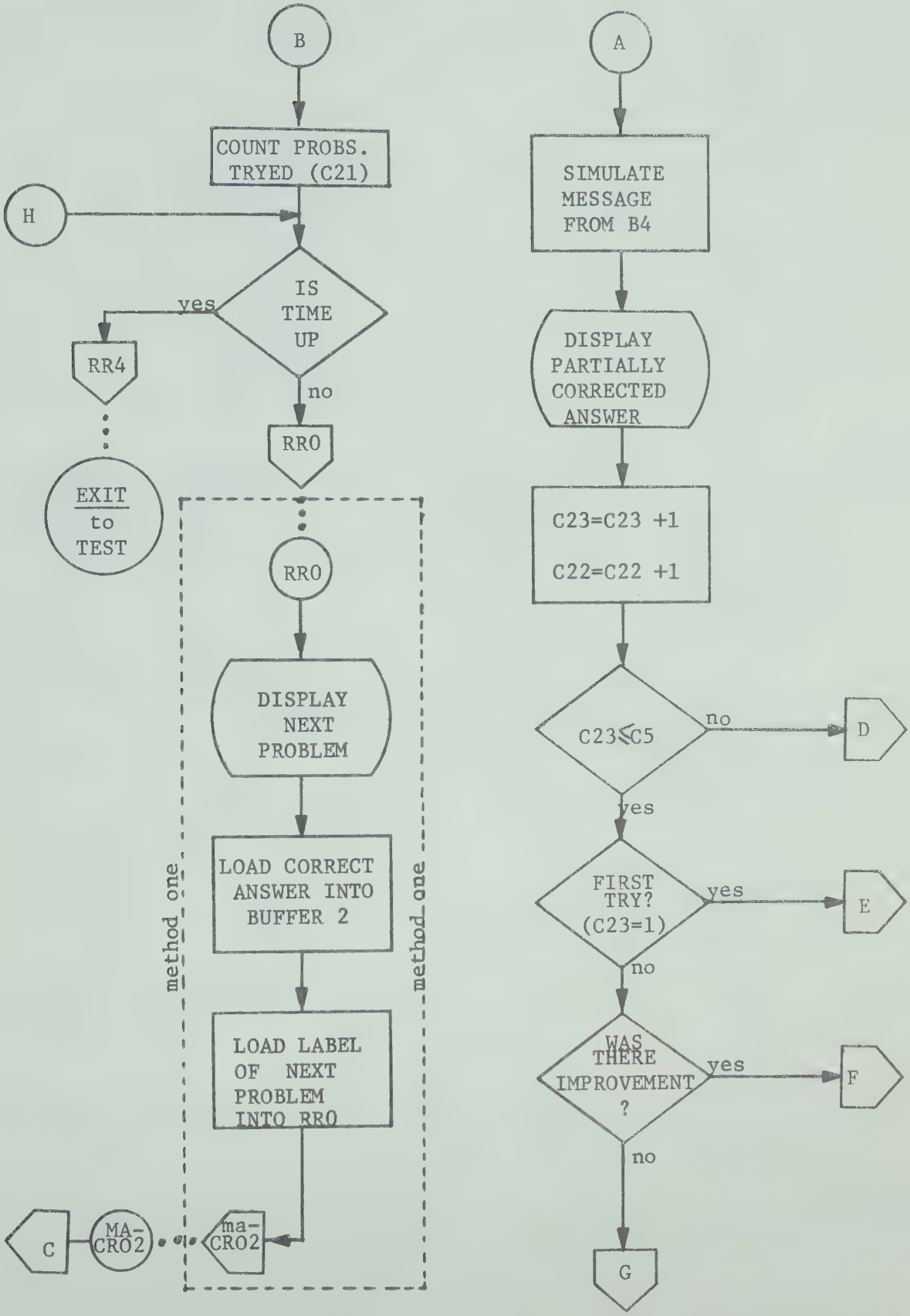

ENTER
MACRO1
D
ARE BUFFER PARAMETERS RIGHT
no
ERROR MESSAGE
STOP
yes
GENERATE RANDOM NO. FOR LOCATION OF RIGHT ANSWER IN B4
C29=RA(0-5)
LOAD LABEL OF CHECKING ROUTINE INTO RR1
LOAD RIGHT ANSWER FROM B1 INTO B4 LOCATION AS STATED IN C29
RR2
RR2
PRESENT TEST OF CURRENT QUESTION
LOAD LABEL OF NEXT QUESTION INTO RR2
RR3
RR3
B
GENERATE THE NO. OF THE WORDS IN B3 FROM WHICH DISTRACTOR #3 AND #4 WILL COME
yes
IS THIS FIRST PASS
no
A
LOAD DISTRACTOR #5 INTO B4
LOAD DISTRACTOR #1 INTO B4
no
IS CORRECT ANSWER IN #5
yes
no
IS CORRECT ANSWER IN #1
GENERATE THE NO. OF THE WORDS IN B5 FROM WHICH DISTRACTORS #1 AND #5 will come
no
IS THIS FIRST PASS
yes
C

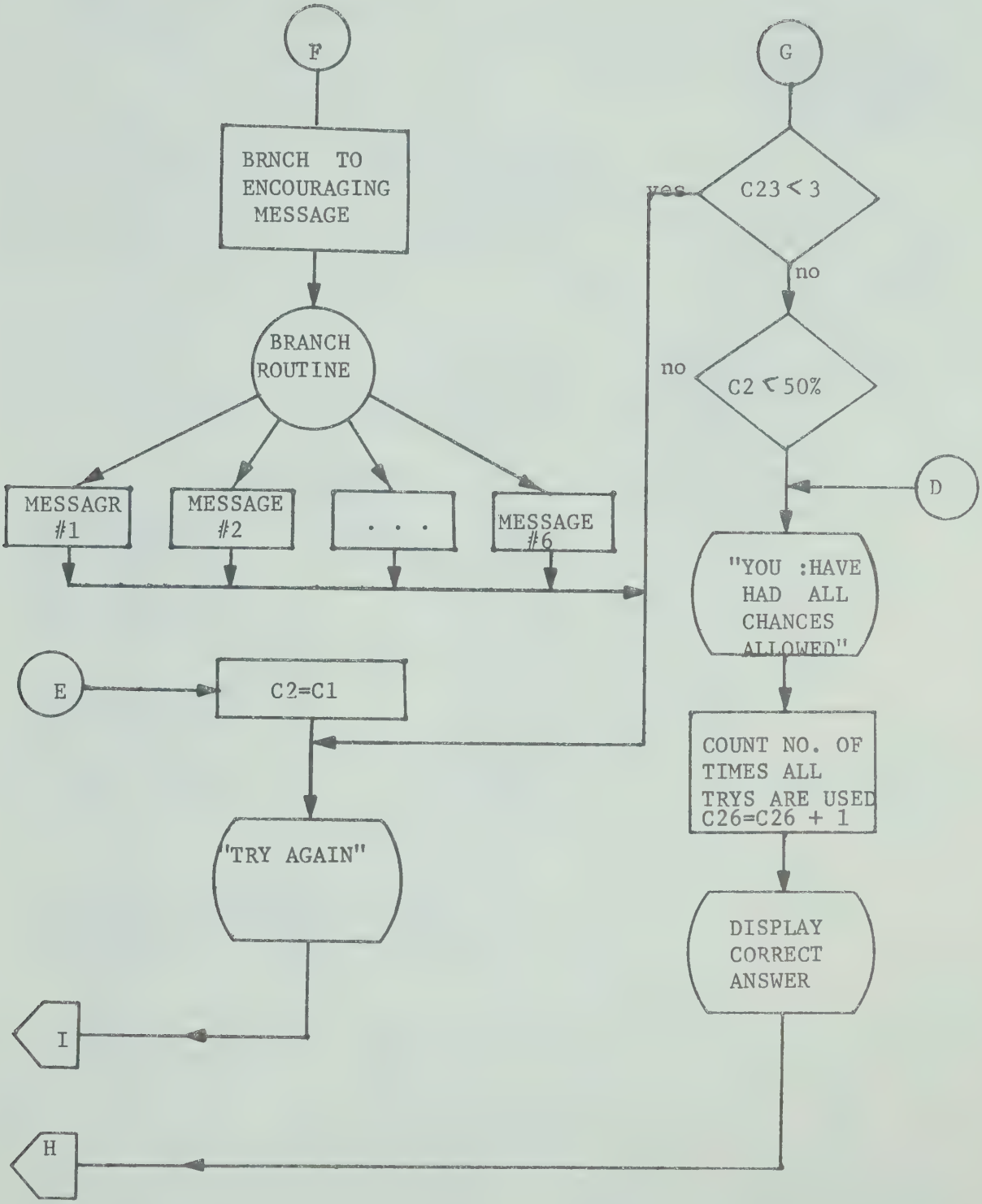

A
B
IS CORRECT ANSWER IN #4
yes
no
IS CORRECT ANSWER IN #3
no
LOAD DISTRACTORS #4 INTO B4
LOAD DISTRACTORS #3 INTO B4
GENERATE THE NUMBER OF THE WORD IN B1 OR B2 FROM WHICH #2 DISTRACTOR WILL COME
IS CORRECT ANSWER IN #2
yes
no
S2=0
no
yes
LOAD DISTRACTOR #2 FROM B1 INTO B4
S2=0
LOAD DISTRACTOR #2 FROM B2 INTO B4
S2=1
IS RESPONSE CORRECT ?
no
yes
C28 = C28+1
INCREMENT QUESTION COUNTER
RR1
RR1
yes
WITHIN ALLOWABLE AREA ?
NO
MESSAGE
MESSAGE
TO IT
600
T2
ARE ALL WORDS IN B1 USED YET ?
no
yes
D
ARE ALL WORDS IN B2 USED ?
LOAD B1 INTO B2 AND B2 INTO B1
DISPLAY SIXTH DISTRACTOR
display FIRST FIVE DISTRACTORS IN B4
time up
RR0
EXIT TEST2
no
IS THIS FIRST PASS
yes
C

METHOD ONE

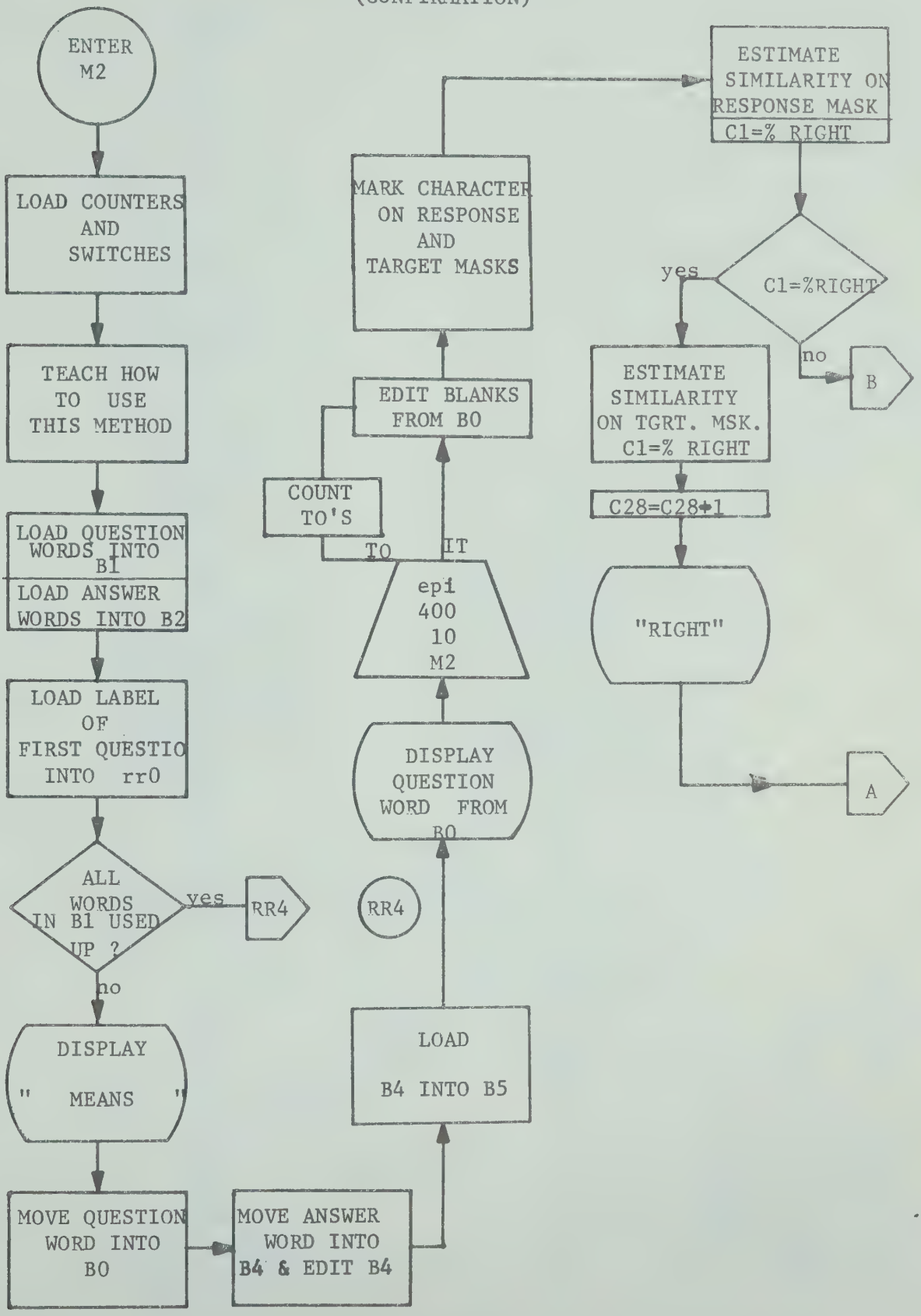

M1
ENTER
INITIALIZE COUNTERS & SWITCHES
TEACH HOW TO DO THIS METHOD
LOAD NO OF INCORRECT TRYS ALLOWED -1 INTO C5
LOAD LABEL OF FIRST QUESTIO INTO RRO
LOAD THE AMOUNT OF TIME ALLOWED C6=250
LOAD CORRECT RESPONSE INTO B2
START CLOCK
DISPLAY QUESTION WORD
RRO
RR.
LOAD ANSW'R WORD INTO B2
LOAD LABEL OF NEXT QUESTION INTO RRO
RRO
not up
CHECK TIME
up
RR4
CORRECT RESPONSE
in time
T.O.
OBTAIN RESPONSE
EXIT TEST
PRESENT PROBLEM
MAC-RO2
MACRO 2
macro2
macro2


ENTER MACRO2
C
I
LOAD COUNTERS AND SWITCHES
epi
450
10
M1
in time
time out
C24=C24+1
IS S4=0 ?
yes
no
S4=1 MESSAGE1
S4=0 MESSAGE2
S25=0
EDIT BLANKS & DOWNSHIFT RESPONSE
MARK ALL MATCHING CHARACTERS
RESULTS OF MC ARE IN B1 & B3 AND ARE A comparison OF THE TARGET AND RESPONSE BUFFERS (B2&B0)
ESTIMATE SIMILARITY ON RESPONSE BUFFER MASK
SET BINARY CODE OF ES IN B4
C1 = %
100% CORRECT ?
yes
no
S25=1
MC7N9876543 MARK ANY 3 OR MORE CORRECT CHARACTERS
ES ON THE TARGET MASK
B4=CODE MATCH
C1=% RICHT
C25=0
yes
A
no
"RIGHT" MESSAGE
COUNT NO. OF CORRECT RESPONSES C28=C28+1
B

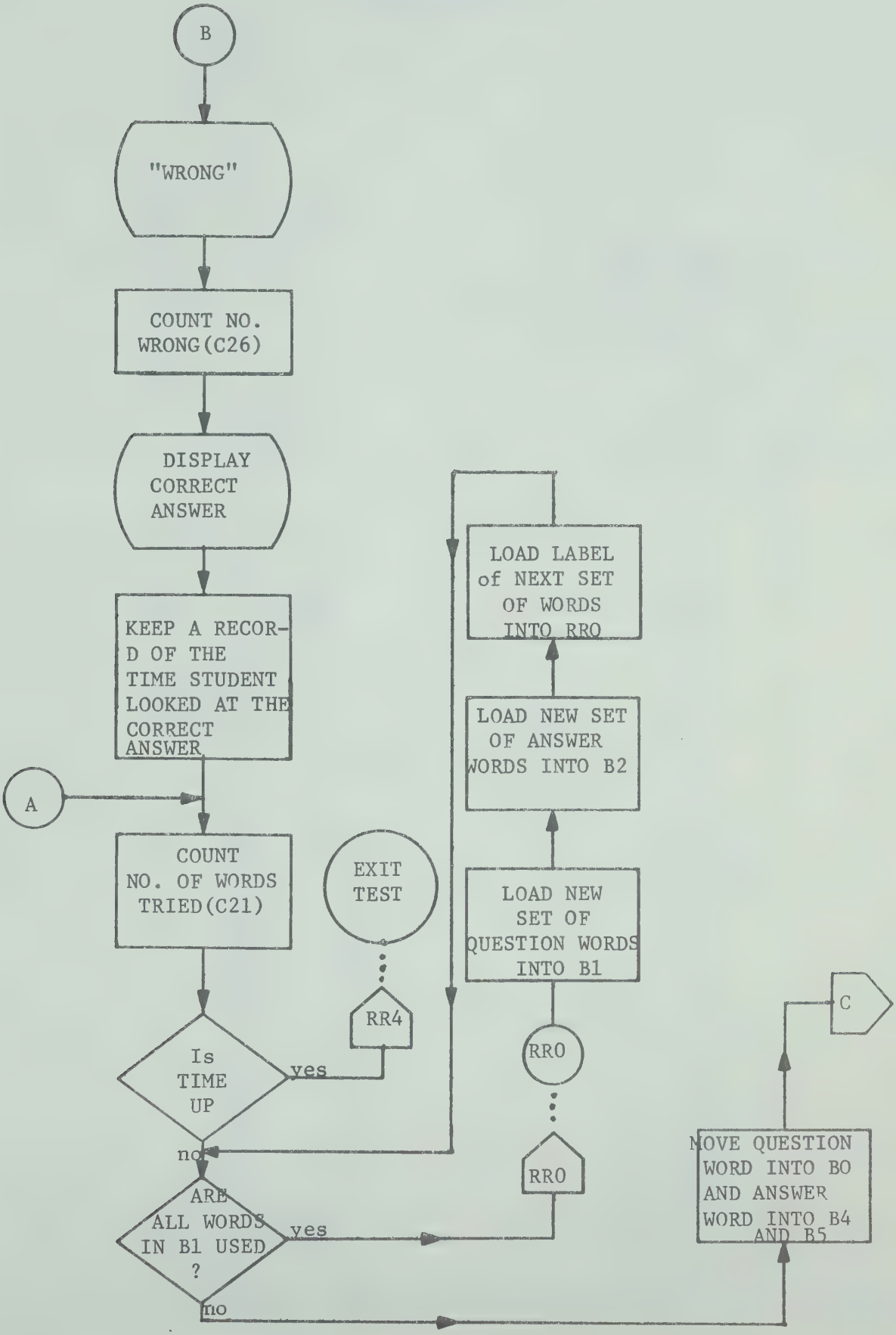

B
COUNT PROBS. TRYED (C21)
H
IS TIME UP
yes
RR4
EXIT to TEST
no
RRO
RRO
DISPLAY NEXT PROBLEM
LOAD CORRECT ANSWER INTO BUFFER 2
LOAD LABEL OF NEXT PROBLEM INTO RRO
method one
method one
C
MA-CRO2
ma-CRO2
A
SIMULATE MESSAGE FROM B4
DISPLAY PARTIALLY CORRECTED ANSWER
C23=C23 +1
C22=C22 +1
C23≤C5
no
D
yes
FIRST TRY? (C23=1)
yes
E
no
WAS THERE IMPROVEMENT ?
yes
F
no
G


F
BRNCH TO ENCOURAGING MESSAGE
BRANCH ROUTINE
MESSAGR #1
MESSAGE #2
. . .
MESSAGE #6
G
C23 < 3
yes
no
C2 < 50%
no
D
"YOU :HAVE HAD ALL CHANCES ALLOWED"
COUNT NO. OF TIMES ALL TRYS ARE USED C26=C26 + 1
DISPLAY CORRECT ANSWER
E
C2=C1
"TRY AGAIN"
I
H

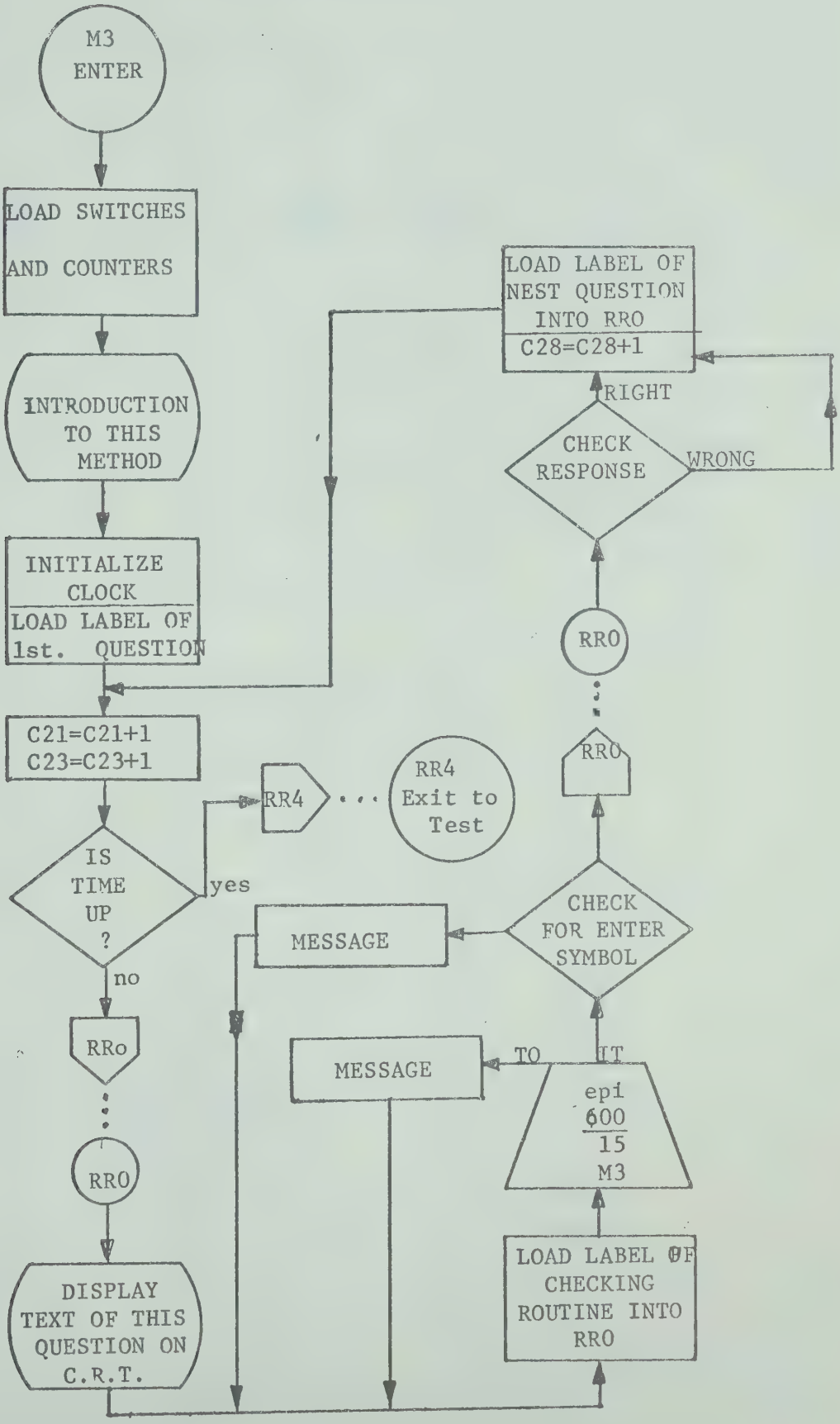
METHOD TWO
(CONFIRMATION)



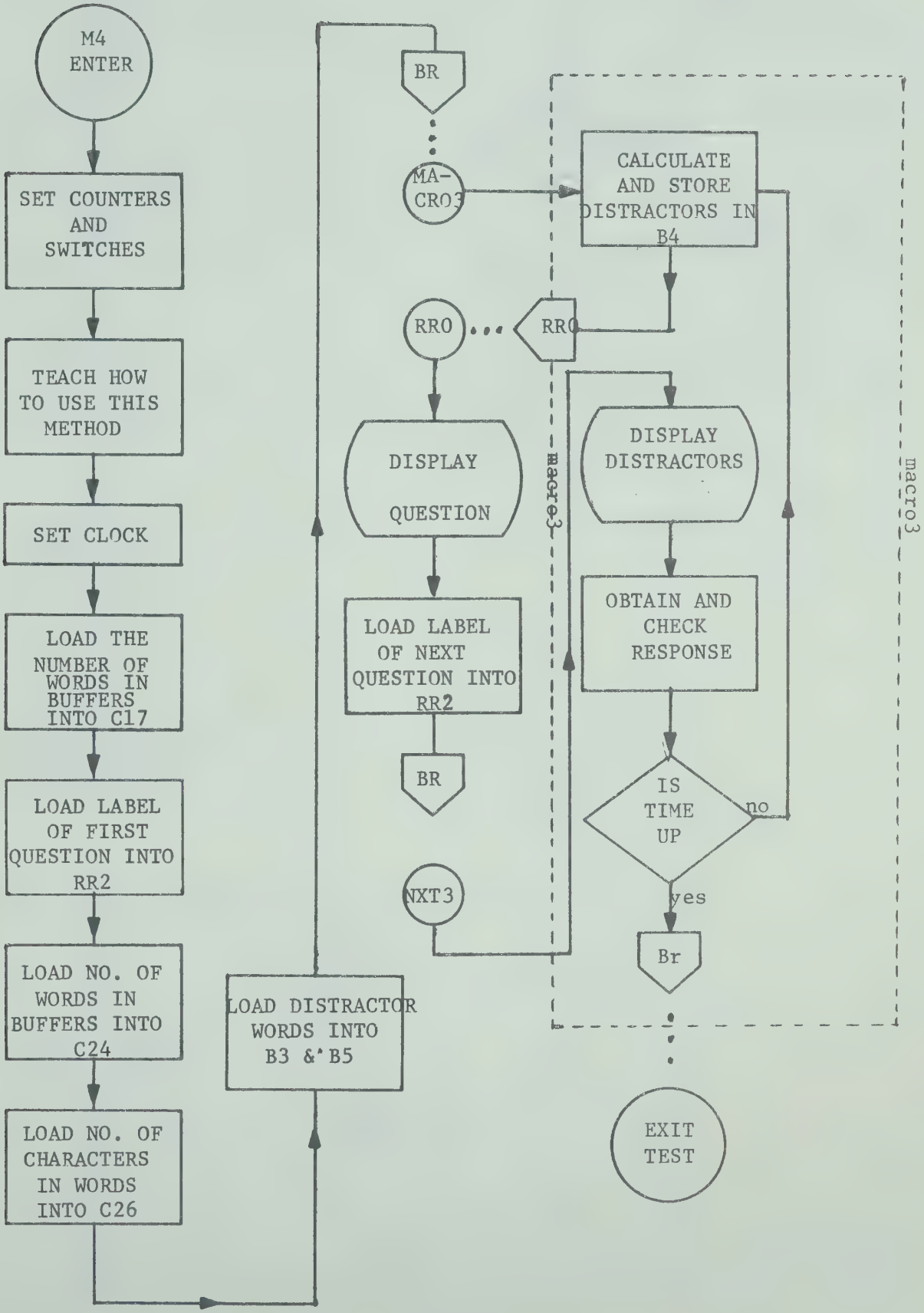
METHOD TWO(CONTINUED)

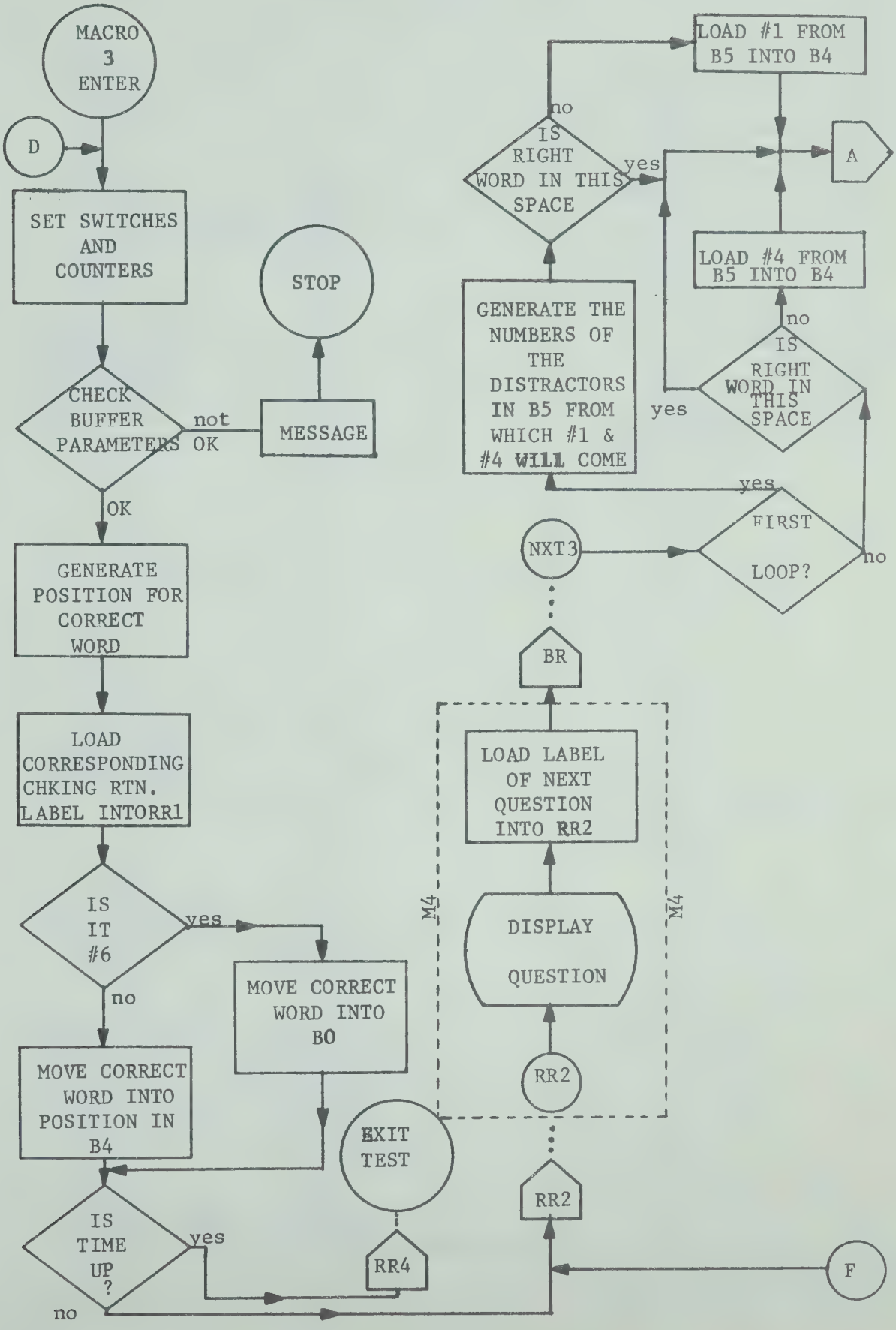


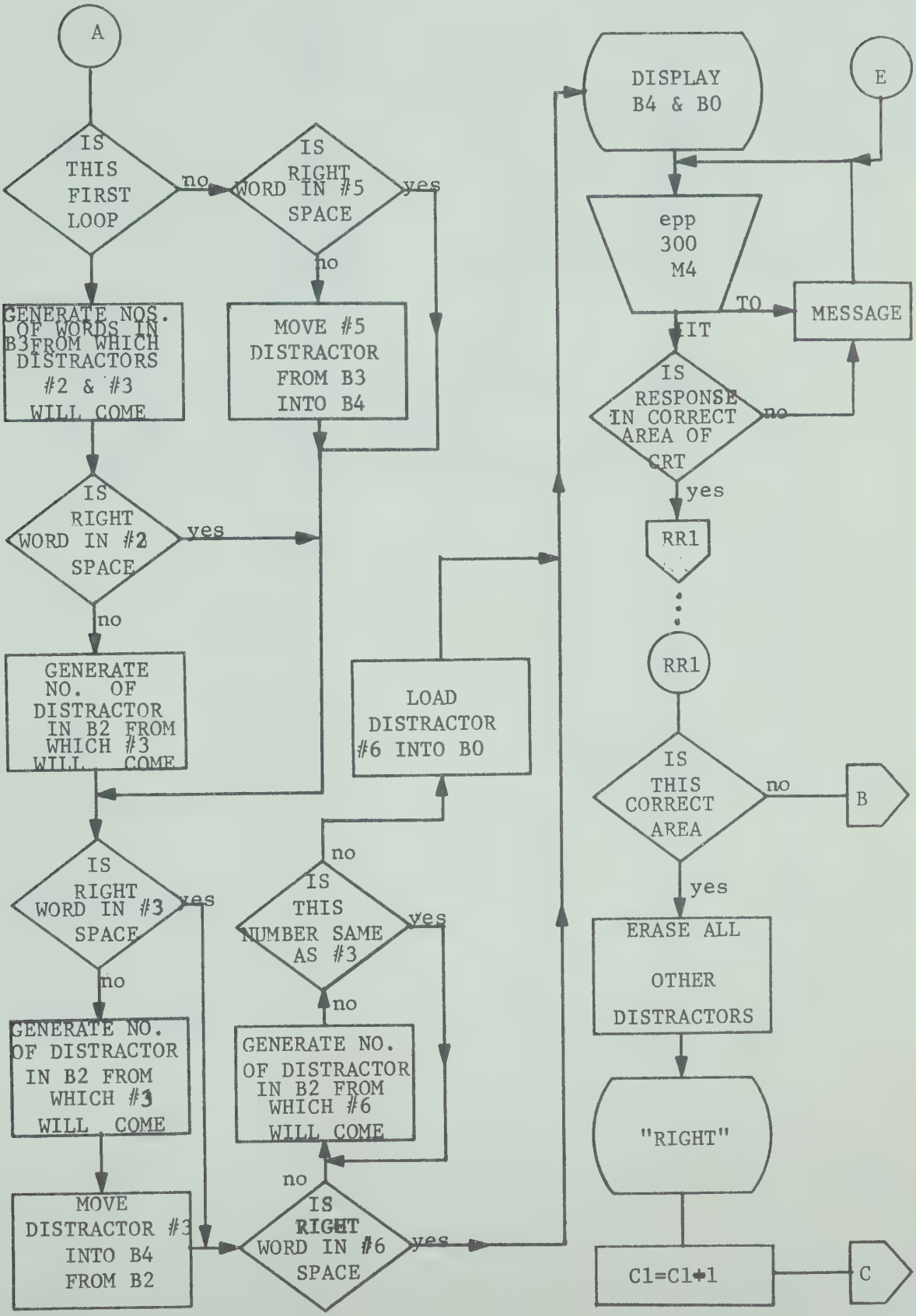
METHOD THREE
(PROMPT)



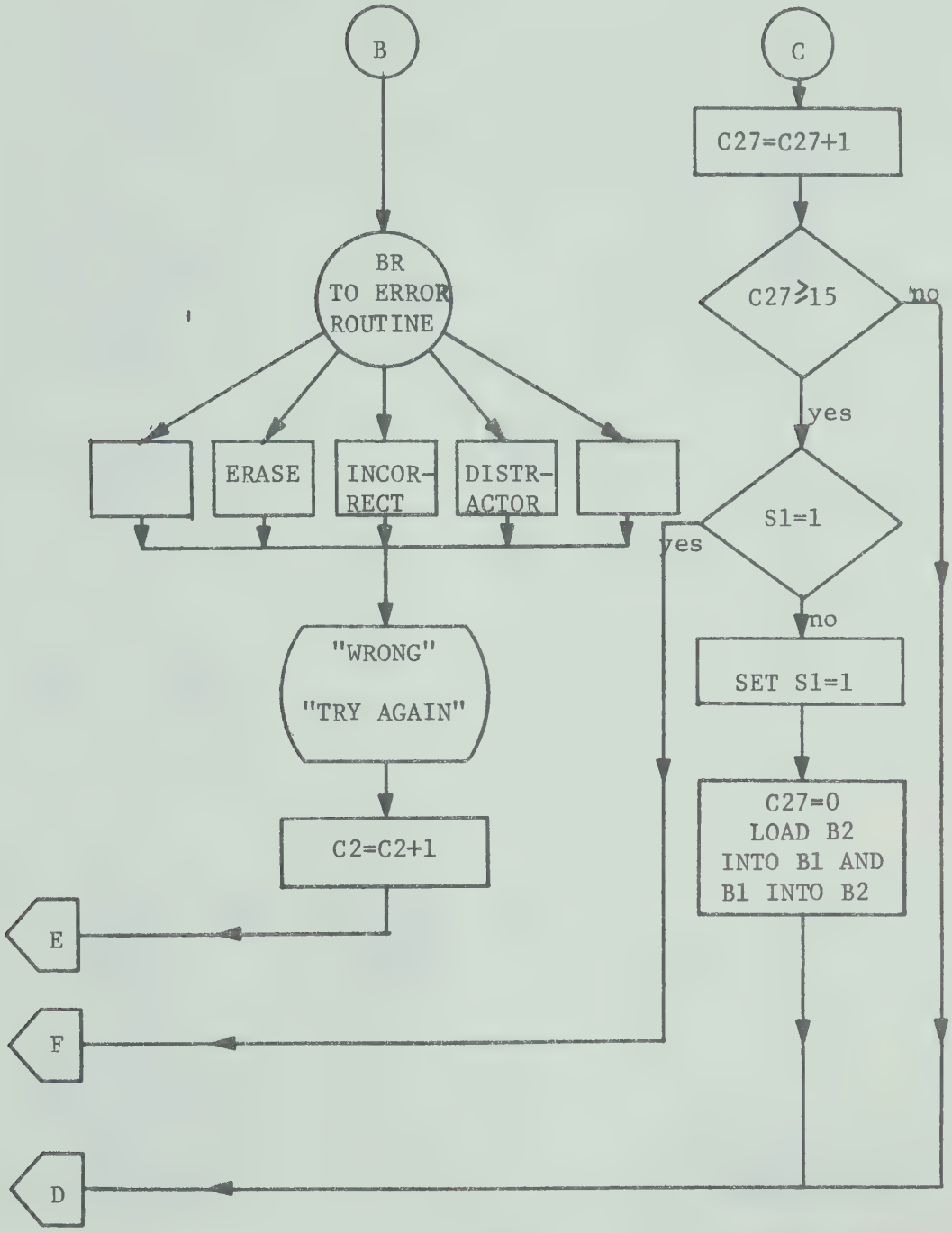
METHOD FOUR
(MULTIPLE CHOICE)

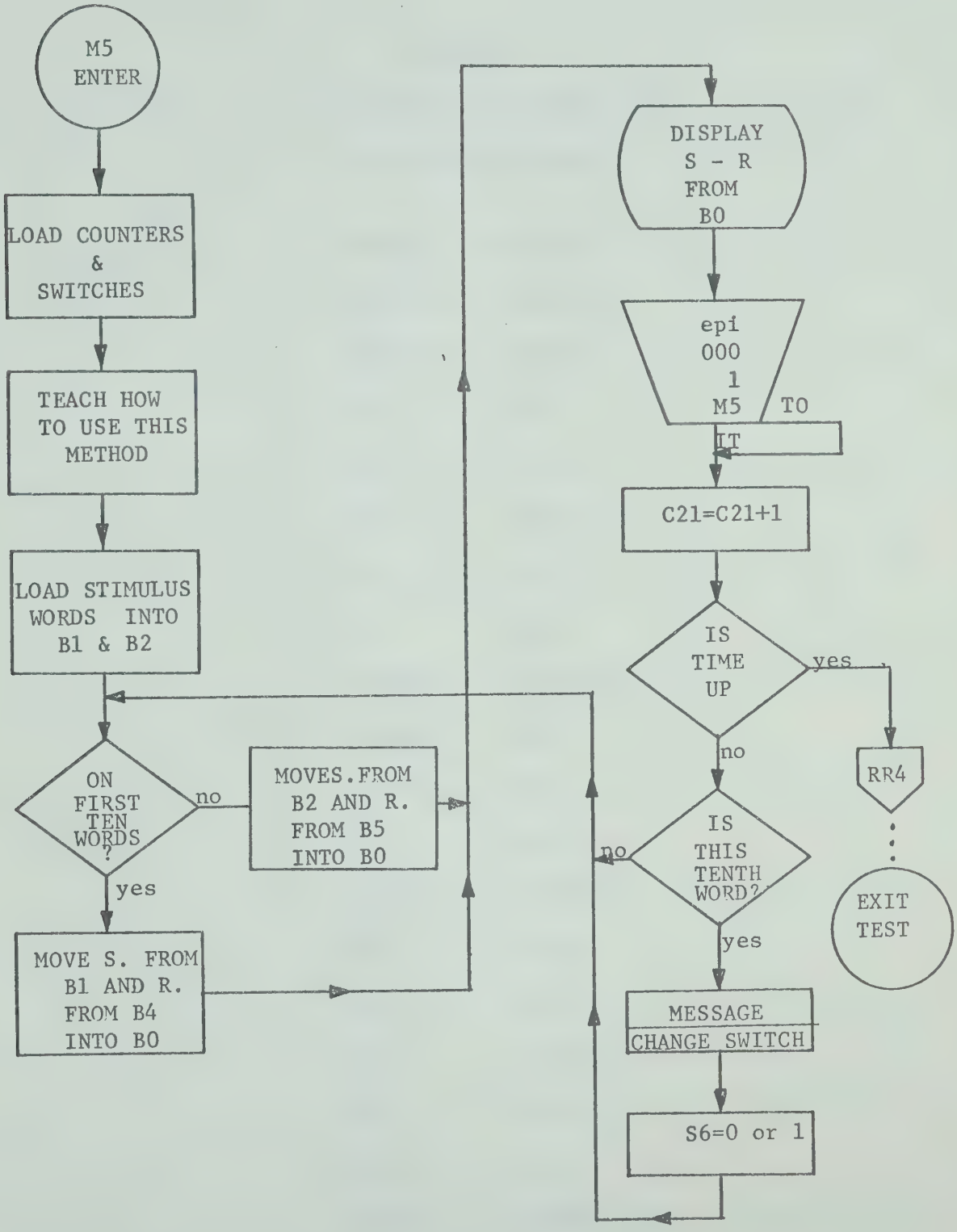



MACRO 3 ENTER
D
SET SWITCHES AND COUNTERS
CHECK BUFFER PARAMETERS OK
not
MESSAGE
STOP
OK
GENERATE POSITION FOR CORRECT WORD
LOAD CORRESPONDING CHKING RTN. LABEL INTORR1
IS IT #6
yes
no
MOVE CORRECT WORD INTO B0
MOVE CORRECT WORD INTO POSITION IN B4
IS TIME UP ?
yes
no
EXIT TEST
RR4
M4
LOAD LABEL OF NEXT QUESTION INTO RR2
DISPLAY QUESTION
RR2
RR2
BR
NXT3
FIRST LOOP?
yes
no
GENERATE THE NUMBERS OF THE DISTRACTORS IN B5 FROM WHICH #1 & #4 WILL COME
IS RIGHT WORD IN THIS SPACE
no
yes
LOAD #1 FROM B5 INTO B4
LOAD #4 FROM B5 INTO B4
IS RIGHT WORD IN THIS SPACE
no
yes
A
F


A
IS THIS FIRST LOOP
no
IS RIGHT WORD IN #5 SPACE
yes
no
GENERATE NOS. OF WORDS IN B3 FROM WHICH DISTRACTORS #2 & #3 WILL COME
MOVE #5 DISTRACTOR FROM B3 INTO B4
IS RIGHT WORD IN #2 SPACE
yes
no
GENERATE NO. OF DISTRACTOR IN B2 FROM WHICH #3 WILL COME
LOAD DISTRACTOR #6 INTO B0
IS RIGHT WORD IN #3 SPACE
yes
no
IS THIS NUMBER SAME AS #3
yes
no
GENERATE NO. OF DISTRACTOR IN B2 FROM WHICH #3 WILL COME
GENERATE NO. OF DISTRACTOR IN B2 FROM WHICH #6 WILL COME
MOVE DISTRACTOR #3 INTO B4 FROM B2
no
IS RIGHT WORD IN #6 SPACE
yes
DISPLAY B4 & B0
E
epp 300 M4
TO
MESSAGE
IT
IS RESPONSE IN CORRECT AREA OF CRT
no
yes
RR1
RR1
IS THIS CORRECT AREA
no
B
yes
ERASE ALL OTHER DISTRACTORS
"RIGHT"
C1=C1+1
C

MACRO3(CONTINUED)




M5
ENTER
LOAD COUNTERS
&
SWITCHES
TEACH HOW
TO USE THIS
METHOD
LOAD STIMULUS
WORDS INTO
B1 & B2
ON
FIRST
TEN
WORDS
?
no
yes
MOVES.FROM
B2 AND R.
FROM B5
INTO B0
MOVE S. FROM
B1 AND R.
FROM B4
INTO B0
DISPLAY
S - R
FROM
B0
epi
000
1
M5
TO
IT
C21=C21+1
IS
TIME
UP
yes
no
RR4
EXIT
TEST
IS
THIS
TENTH
WORD?
no
yes
MESSAGE
CHANGE SWITCH
S6=0 or 1

APPENDIX D

THE PAIRED-ASSOCIATES USED IN THIS EXPERIMENT

1. CAPITAL - CAPITIS
2. BUILDING - AEDIFICIUM
3. BRIDGE - PONTIS
4. BOY - PUER
5. CAMP - CASTRA
6. ARMY - EXERCITUS
7. DEEP - ALTUS
8. DOG - CANIS
9. FARMER - AGRICOLA
10. FATHER - PATER
11. FIELD - AGER
12. FIRE - IGINIS
13. MAIDEN - VIRGINIS
14. HAND - MANUS
15. HEAD - CAPUT
16. HILL - CALLIS
17. HOME - DOMUS
18. HORSE - EQUUS
19. HUNDRED - CENTUM
20. IRON - FERRUM

APPENDIX E

CONTEXTUAL PRESENTATIONS FOR METHOD THREE

The capital of a country is called a capitis in our new language. If you were to take a journey to the capital it would be known as an itineris. The bus that you would travel on would be a toto.
A capital is a _____.

A bridge is a pontis, a market-place is a forum and a building an aedificium.
A building is a _____.

The house, or domus, of the boy, or puer, was located by a bridge which, in our new language is called a pontis.
A bridge is called a _____.

A family in our new language is called a familia while a boy is a puer and a girl is a pueress.
A boy is a _____.

The boy made camp, which is a castra, then proceeded to talk to the farmer or agricola who had just come across the field or ager.
A camp is a _____.

The army, which is called exercitus, left the city to chase a dog, a canis. The dog was caught in a field, an ager.
The army is called _____.

A boy, who is a puer, jumped down a deep, or altus, well when he saw the fire, or ignis coming.
Deep means _____.

A farmer or agricola looked across the field or ager and saw a dog which is a canis in our new language.
A dog is called a _____.

Hand is called manus in our new language while farmer is known as agricola and hundred is centum.
A farmer is an _____.

A father who is called a pater once went up a hill, or callis, to build himself a home or domus.
A father is called _____.

A man, who is a manus, put his hand to his caput. That is, he put his hand to his head. He did this as he walked across the ager or field.
A field is a _____.

The horse, or equus, could run like wild fire and he belonged to a maiden. That is to say he could run like wild iginis. The horse belonged to a virginis.
A fire is called _____.

The boy had a manus of iron. Or, to put it another way he had a hand of ferrum. He liked to dig deep holes. That means he like to dig altus holes. So he tried to join the exercitus or army.
A hand is known as _____.

The meaning for the word caput is given in the last sentence of this paragraph. When a dog or canis attacks a camp it is said to have attacked a castra. It means head.
A head is a _____.

The army, or exercitus, advanced up the callis to attack the agricola, or farmer. The farmer was on the hill that the army advanced up.
A hill is a _____.

Father, on the way domus, fell in an altus or hole. We could also say, pater on the way home fell in a deep hole. It cost him one centum ($100) dollars to have it fixed.
A home is called _____.

Pater bought an equus for one hundred dollars. What father bought was a horse. It had a deep, or altus, brown spot on its caput. It had a spot on its head.
A horse is an _____.

One hundred delegates from the capital, or capitis, city voted yes to have the aedificium made of iron. Centum delegates voted yes to have a ferrum building.
Hundred means _____.

A domus made of ferrum would make any virginis feel better than if she had to live in a field, or castra. That is, a maiden prefers a house made of iron to living in a field.
Iron means _____.

The aedificium caught on fire and left the virginis homeless. It cost one hundred, or one centum dollars to replace the building which caught on iginis and left the maiden homeless.
A maiden is a _____.